INSTRUCTION MANUAL

type 1395-P5

NRZ CONVERTER/SAMPLER

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Form 1395-9605-A February, 1968

GENERAL RADIO COMPANY

West Concord, Massachusetts

specifications

(see also specifications for 1395-A)

SAMPLING INPUT

Pulses: 10 to 15 V, positive-going, 75- to 150-ns duration, dc to 2.5 MHz.

Sine Wave: At least 17 V rms, 1 to 2.5 MHz. Sine-wave sampling below 1 MHz not recommended.

Input Impedance: Approx 4500 Ω across 40 pF.

SAMPLED INPUT

Sensitivity: 0.2 V pk-pk up to 2.5 MHz, optimized by adjustment of threshold control. Input required increases at other settings.

Coupling: Ac or dc, switch-selected.

Threshold Control: Compensates for dc components between approx ±0.6 V.

Input Impedance: Approx 100 kΩ across 40 pF.

NRZ OUTPUTS Both positive- and negative-going transitions are available simultaneously with the dc component controlled by the 1395-A.

Amplitude: >20 V, open circuit: >1 V across 50 Ω.

Transition Times: <15 ns with 50-Ω load at max input. Typically 80 ns + 2 ns/pF of load capacitance for high-impedance loads.

Output Impedance: 1 kΩ max.

TRIGGER OUTPUTS Two outputs available simultaneously: pulse generated when SAMPLED terminal is in ONE state, another when terminal is in ZERO state.

Amplitude: >+10 V. **Duration:** Approx 70 ns.

Output Impedance: Approx 160 Ω.

Delays: Trigger and NRZ outputs are delayed approx 190 ns from the SAMPLING input.

Accessories Supplied: Eight patch cords — two each Types 274-LMB, 274-LMR, 274-LSB, 274-LSR; two double plugs, four insulated plugs.

Catalog Number	Description
1395-9605	**1395-P5 NRZ Converter/Sampler**

SECTION 1

INTRODUCTION

1.1 THE TYPE 1395-A MODULAR PULSE GENERATOR SYSTEM.

The General Radio Type 1395-A Modular Pulse Generator is a customized pulse generator made up of a main frame, which includes power supplies and adder circuits, and various plug-in modules. As requirements change, the plug-in modules can be rearranged in a few minutes to create exactly the pulse generator for the new circumstances. The Type 1395-P5 NRZ Converter/Sampler described in this instruction book is one of the plug-in modules.

1.2 DESCRIPTION OF THE NRZ CONVERTER/SAMPLER.

The Type 1395-P5 NRZ Converter/Sampler (Figure 1-1) is primarily designed for use with the 1395-P6 Word Generator module to produce Non-Return-to-Zero (NRZ) signals. Secondarily, it is a module with binary decision-making capability. For a given voltage level on the SAMPLED terminal, either a ONE or ZERO decision appears at the various output terminals in response to an interrogating pulse applied to the SAMPLING input.

The NRZ outputs are available either as voltages positive-going for ONES or voltages positive-going for ZEROS. Trigger pulses are also available as an alternate form of output. These appear on the two separate TRIGGER PULSES terminals, one giving a trigger pulse when a ONE is at the SAMPLED INPUT, the other, when a ZERO is at the SAMPLED INPUT. The NRZ outputs are adjustable in amplitude, but their durations are determined by the time between successive SAMPLING INPUT pulses. The trigger-pulse amplitude and duration are fixed at approximately 13 V and 100 ns. These pulses are normally used to trigger other modules in the 1395 family, such as the 1395-P2 Pulse/Delay Unit or the 1395-P3 Pulse Shaper.

1.3 ONE AND ZERO STATES DEFINED.

A ONE or "1" state is a relatively positive voltage at the SAMPLED INPUT terminal. For example, if at the moment a pulse is applied to the SAMPLING INPUT, the potential at SAMPLED INPUT is +5 V, the instrument will consider the SAMPLED INPUT to be in the ONE state, and the output jacks will carry voltages and trigger pulses accordingly. If the

SAMPLED INPUT had been at -5 V, the instrument would have decided a ZERO or "0" condition existed, and given appropriate outputs. The +5 and -5 V are merely numbers picked at random as examples. If the THRES ADJ control is set to center the decision-making at a slightly negative level, for instance, then a voltage of -0.2 V might be adjudged the ONE state and -0.7 V the ZERO state. The point to remember is that the more positive condition at the SAMPLED INPUT is ONE and the less positive condition is ZERO.

The circuits in the NRZ Converter/Sampler unit include the following basic functional subassemblies:

a. Input circuits, buffers, limiters
b. First sample and hold
c. Delayed sampler of the stored state in "hold"
d. Output circuits for both NRZ and trigger pulses

1.4 CONTROLS AND CONNECTORS.

All controls and connection points required for operation of the NRZ Converter/Sampler are on the front panel (see Figure 1-1). Table 1-1 identifies these controls and connectors.

1.5 STORAGE OF SPACE MODULES.

The modules of the 1395 family are shipped sandwiched between sheets of plastic foam. These sheets of foam fit cross-wise in a standard filing cabinet, as do the manila folders commonly used for 8-1/2 by 11 papers. Slip unused modules between foam sheets and store them in a file drawer. They will remain clean and protected, and positioned so that the module type is instantly recognized. If the foam sheets loosen from frequent handling, an elastic band will hold them in place.

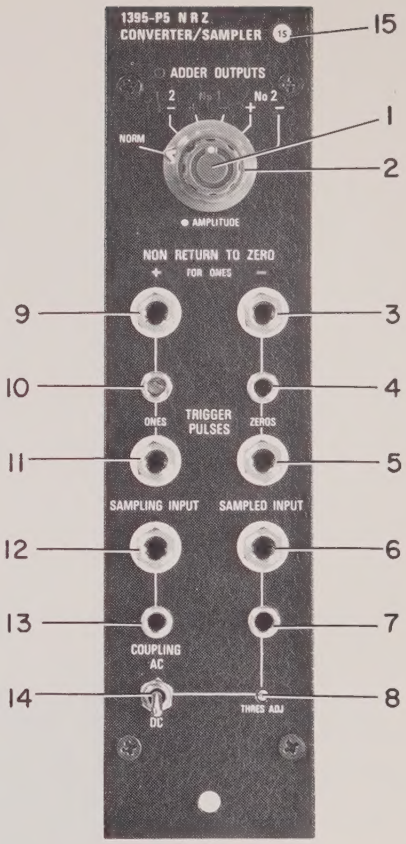


Figure 1-1. The Type 1395-P5 NRZ Converter/Sampler. (For legend, refer to paragraph 1.4.)

TABLE 1-1
CONTROLS AND CONNECTORS

Figure 1-1 Reference	*Name*	*Type*	*Function*
1	AMPLITUDE	Continuous rotary control	Adjusts amplitude of Non-Return-to-Zero (NRZ) output pulses.
2	ADDER OUTPUTS	6-position rotary switch	Routes NRZ output pulses to selected adder bus. Polarity marks refer to ONES state. In NORM, adder busses disconnected.
3	NRZ – FOR ONES	Jack*	Output terminal for NRZ pulses that are at low potential for ONES state.
4	none	Jack	Ground terminal.
5	ZEROS TRIGGER PULSES	Jack	Output terminal for trigger pulses pulses generated when SAMPLED input is in ZERO state.
6	SAMPLED INPUT	Jack	Input terminal for voltage being tested for ONE and ZERO levels.
7	none	Jack	Ground terminal.
8	THRES ADJ	Continuous rotary control	Sets level at which a ONE or ZERO decision is made.
9	NRZ + FOR ONES	Jack	Output terminal for NRZ pulses that are at high potential for ONES state.
10	none	Jack	Ground terminal.
11	ONES TRIGGER PULSES	Jack	Output terminal for trigger pulses generated when SAMPLED input is in ONE state.
12	SAMPLING INPUT	Jack	Input pulses at this terminal give the the command to take a sample.
13	none	Jack	Ground terminal.
14	COUPLING	Toggle switch	Determines whether path from SAMPLED INPUT to internal circuits is direct- or capacitor-coupled.
15	none		Write-on tab for identification of module in large set-ups.

*All jacks accept Type 274 banana plugs.

SECTION 2

OPERATING PROCEDURE

CAUTION
TURN OFF THE POWER BEFORE YOU INSERT OR REMOVE ANY MODULE

2.1 POWER CONNECTIONS.

Four voltages must be supplied to operate the Type 1395-P5 NRZ Converter/Sampler: -150 V dc at 25 mA; 6.3 V ac at 1.6 A, offset from ground by -75 V dc; +15 V dc at approximately 4 mA; and 0 to +20 V dc variable, at 25 mA. This power is normally supplied through a 14-pin connector in the Type 1395-A main frame. The Converter/Sampler can be placed in any of the seven positions delineated by the small raised guides on the floor of the main frame. The user's convenience and required interconnections with other 1395-series modules are the sole factors that determine position.

To connect to the Type 1395-A power supplies, slide the NRZ Converter/Sampler into the Modular Pulse Generator. When the NRZ Converter/Sampler Unit is almost fully inserted, make sure that the power connectors are mated, then push it in firmly and fasten the thumbscrew on the bottom edge of the panel.

Operation of an NRZ Converter/Sampler Unit outside the Type 1395-A main frame is not recommended. The exposed circuitry represents a shock hazard and is vulnerable to damage. External connections can create crosstalk and stray capacitance that yield unsatisfactory performance because, at all settings of the ADDER switch except NORM, or with a Type 1395-P6 Word Generator in the system, pulses, as well as power, travel to and from the rear plug. If external connection to the rear plug is unavoidable, use an Amphenol connector, Number 57-20140 or equivalent.

2.2 INTERCONNECTION WITH OTHER MODULES.

2.2.1 GENERAL.

Inasmuch as the Type 1395-A Modular Pulse Generator permits as much versatility as possible in assembly of pulse-generating equipment, this book cannot possibly cover all interconnections, or even a generous assortment of them. However, some samples are described in the following paragraphs.

2.2.2 KEEPING TRACK OF THE MODULES.

The aluminum-foil tab (15 in Figure 1-2) has a slightly roughened surface to take marks from an ordinary lead pencil. When a Type 1395 system involves many modules, it is handy to number the individual plug-ins on both an interconnection sketch and these aluminum tabs.

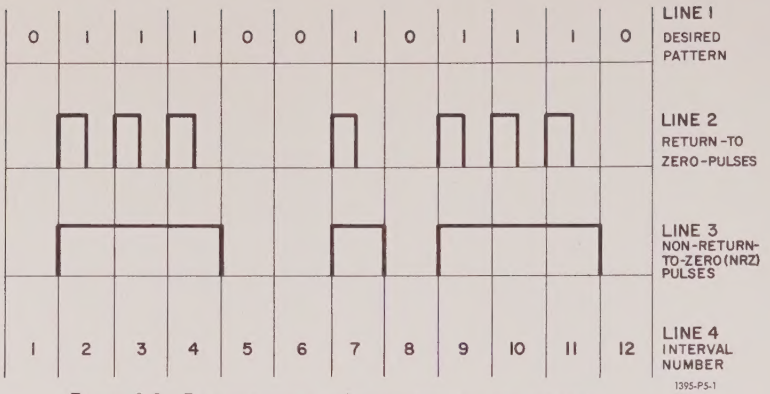


Figure 2-1. Return-to-zero and non-return-to-zero patterns.

2.2.3 DEFINITION.

Figure 2-1 compares return-to-zero and non-return-to-zero pulse patterns. Line 1 is a binary word consisting of the sequence of bits 011100101110. Line 2 shows one way such a pattern could look on an oscilloscope. Each time the word contains a "1", a pulse rises from the baseline to a more positive value, the ONE state, stays at the new value for a time less than the full interval allowed for each bit, and then drops back to the baseline or ZERO state. Exactly because it does drop back, this is a Return-to-Zero pulse pattern. Now on Line 3, we see a pattern in which a voltage, once established in the ONE state, does not die back to the baseline until an actual "0" is found in the binary code. At the start of interval 2, for example, a "1" is found in the desired pattern; intervals 3 and 4 each contain a "1" as well. The signal at the NRZ output therefore remains at full voltage until the start of interval 5. This is the NRZ (Non-Return-to-Zero) signal: one in which the pulses do not return to the baseline or ZERO state until they are forced back by the appearance of a "0" in the code.

The term "full-baud" may be encountered in binary-signal descriptions. The word derives from the name of Mr. J. M. E. Baudot, a French inventor. Baud represents, strictly speaking, the signalling speed in dots per second, or in modern binary codes number of bits per second. In Figure 2-1, if one second were allowed for the 12 bits shown, we would say the signalling rate was 12 bauds.*

The word "baud" has with some degree of acceptance come to mean not only signalling rate, but the individual interval of time allowed for a bit. If we admit this second definition, then a full-baud pulse lasts the entire time allowed for a bit of information. In other words, Non-Return-to-Zero and full-baud are one and the same thing. Pursuing this usage of baud, the pulses on line 2 of Figure 2-1 would be "half-baud." This provides a very convenient way of expressing the duty ratio of a pulse, as long as one understands the context, and does not think, for example, that half-baud means a signalling speed one-half the customary rate on a given channel.

2.2.4 GENERATION OF THE NRZ PATTERN.

The connections among modules necessary to generate NRZ patterns are shown in Figure 2-2. Just for illustration, the bit rate is 10,000 bits per second. The Type 1395-P1 PRF Unit generates pulses at this rate, and acts as a master clock for the system. The

*Note that baud is like the term knot for stating speeds of wind or ships. A knot is one nautical mile per hour; the per unit time is included in the word. "Knots per hour" is an incorrect term, unless one refers to acceleration, not velocity. Likewise, bauds per second would be incorrect.

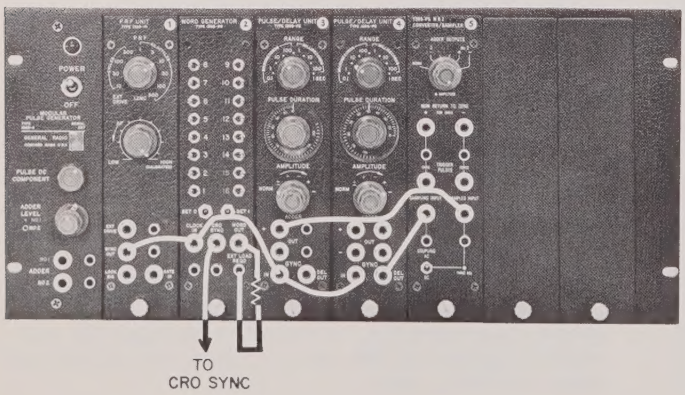


Figure 2-2. Interconnections for generating a binary NRZ pattern.

Type 1395-P6 Word Generator determines the binary pattern in response to the settings of its switches.

NOTE

Full details of the use of the Type 1395-P6, and other modules, are found in theri respective instruction manual sections.

Following the Word Generator, two Type 1395-P2 Pulse/Delay Units come into play. The first one, which has number 3 on the tab in the top right-hand corner, generates a pulse. Just for example, the duration of this pulse has been set to 10 μs. The output of this Pulse/Delay Unit is the samplED signal for the NRZ Converter.

The samplING signal is the output of Pulse/Delay Unit number 4. The delay through this unit is 5 μs. This means that a stream of pulses, delayed 5 μs from the master clock, comes from the DEL OUT terminal and enters the SAMPLING INPUT of the NRZ Converter/Sampler. These delayed pulses will fall right in the middle of the 10-μs pulses from Unit 3. The delay adjustment is not at all critical, since there is a margin of 5 μs either way. The NRZ output is taken from the + FOR ONES terminal or the - FOR ONES terminal, as desired. The TRIGGER PULSES are available simultaneously. The ONES TRIGGER PULSES terminal gives a narrow, spiky pulse for each ONE in the incoming samplED signal, and the ZEROS TRIGGER PULSES terminal gives a similar pulse for each ZERO in the samplED signal. Remember that in NRZ, if several ONES or ZEROS in a row are generated, there will be a continuous voltage at the NRZ output; however, a trigger pulse is generated for each and every ONE or ZERO, even if there is no simultaneous change in the state of the NRZ output terminal.

Figure 2-3 shows the NRZ pulses obtained from this system at the + FOR ONES output. The pattern is 0110011111001000101.

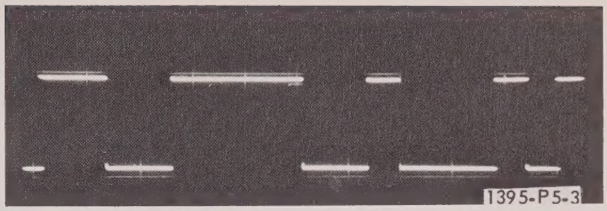


Figure 2-3. Non-return-to-zero pulses, + FOR ONES. Pattern is 0110011111001000101.

2.2.5 DIPULSE, DIPHASE, NRZI.

The various types of pulse transmissions have characteristic advantages and drawbacks. These are related to the ability of a receiving terminal to extract synchronizing information, and the ability of intermediate devices, such as pulse repeaters, to amplify the various forms of signals. For example, NRZ consisting of a long string of ONES or ZEROS will temporarily appear to be dc. If a repeater has any capacitor- or transformer-coupled stages (and most do), this NRZ will not be passed. Nor will the receiver be able to stay phase-locked to the bit rate of the message if only dc is received for any extended period of time. To eliminate these difficulties, several types of binary patterns other than Return-to-Zero and Non-Return-to-Zero are available. Three of these are shown in Figure 2-4.

The top line of this figure illustrates DIPULSE. This consists of pulses having both a top and a bottom for ONES; no existence for ZEROS. These pulses pass through ac-coupled circuits with no trouble because they are symmetrical. No baseline shift can occur as a result of the pattern. A long sequence of ZEROS, of course, is a long sequence of no transmission at all. The receiving terminal will lose "sync" sooner or later.

One of several forms of DIPHASE is pictured on the second line of Figure 2-4. This is often called

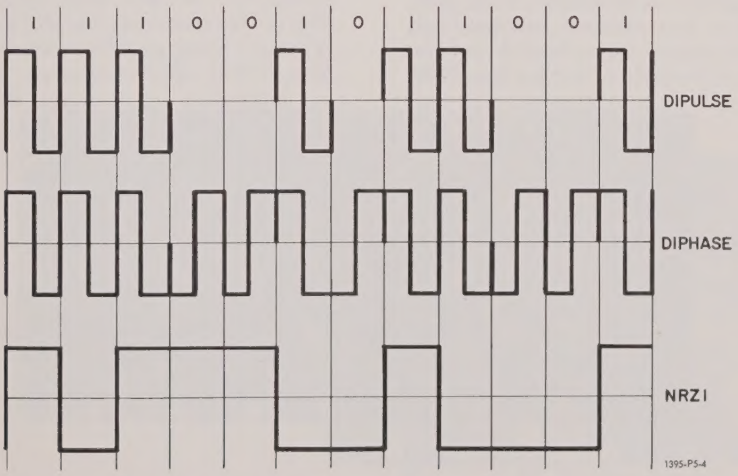


Figure 2-4. Dipulse, diphase, and NRZI patterns.

Manchester coding.* If the pulses shown there are imagined not to be pulses, but rather to have rounded sides, it will be seen that a ONE is analogous to one cycle of a sine wave, and a ZERO to one cycle of a negative sine wave. Diphase passes easily through ac-coupled circuits, but timing extraction is complicated by the fact that if the signal just as it is shown in the figure is sent to a filter, the energy from ONES is exactly out of phase with the energy from ZEROS, and the filter will give no output if the number of ONES and ZEROS is equal when averaged over a length of time of the order of the reciprocal of the filter bandwidth. There are various ways around this problem; it is mentioned at all only to point out that diphase has its own characteristic troubles. Its advantage, beyond the ready passage through ac-coupled circuits, is that, given proper methods for extracting it, the sync information is always available. Diphase systems are perfectly happy with an infinitely long sequence of all ONES or all ZEROS.

One drawback to conventional NRZ data representation is that if a flip-flop misses a transition, all subsequent pulses wil be upside-down. All ZEROS will look like ONES and vice-versa. This problem is prevented by NRZI (Non-Return-to-Zero-Inverted), shown on the third line of Figure 2-4. In this pattern, a ONE is represented by a change of state, and a ZERO by having nothing happen at all. If the whole pattern should get upside down, it makes no difference (except, of course, the single bit that was in error at the moment when the pattern was accidentally inverted). NRZI has some of the drawbacks of regular NRZ as far as extracting timing and passing through ac-coupled repeaters are concerned: a long sequence of ZEROS looks like dc to the transmission system and will eventually cause loss of sync at the receiving terminal. A long sequence of ONES is harmless; in fact, ideal.

2.2.6 GENERATION OF DIPULSE, DIPHASE, NRZI.

Dipulse and NRZI do not require the 1395-P5 NRZ Converter/Sampler module. Nevertheless, this seems like a convenient place to describe how to generate them with the Type 1395-A Modular Pulse Generator. Dipulse and NRZI are very easy to synthesize.

Dipulse is generated by the use of two Type 1395-P2 Pulse/Delay Units immediately after the Type 1395-P6 Word Generator. The WORD OUT pulses are used for triggering the number 3 Pulse/Delay Unit as shown in Figure 2-5. The delay produced by this unit is set to 50 μs because the period is 100 μs and each half of the dipulse should be half the period. At the end of 50 μs the DEL OUT pulse from module 3 triggers module 4. Module 3 is connected to send a positive-going pulse to the adder; module 4 sends a negative-going pulse that starts as soon as the positive-going pulse ends (save for a time lag of about 60 ns). The sum of these pulses, taken from the ADDER NO. 1 output, is the desired dipulse. This output may be used "as is," or increased in level with the Type 1395-P4 Power Amplifier. The dipulse signal is perfectly compatible with the Power Amplifier, because it introduces no baseline shift (*cf.* paragraph 2.3.5 in the instruction book for the Type 1395-P4 Power Amplifier). Figure 2-6 shows a dipulse pattern, in this example 110111100 and most of another "1."

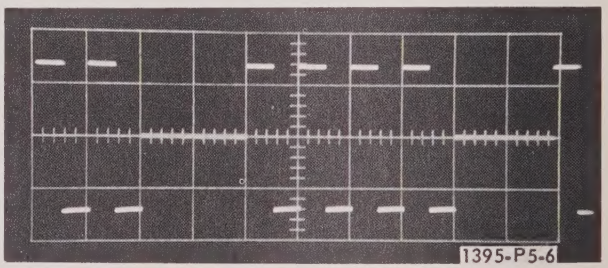


Figure 2-6. An example of a dipulse pattern.

NRZI or Manchester coding is the easiest of the binary transmissions to generate with the Type 1395-A Modular Pulse Generator. The connections are shown in Figure 2-7. Since the Type 1395-P3 Pulse Shaper changes state every time a pulse is applied to its IN-1 terminal, if no pulses are applied in the meantime to the IN-2 terminal, it is only necessary to connect the WORD OUT terminal of the Word Generator to the IN-1 terminal of the Pulse Shaper. Since a ONE is associated with a pulse from the WORD OUT terminal, each ONE will cause a

*Athey, Skipwith W., "Magnetic Tape Recording," National Aeronautics and Space Administration, Washington, D. C., 1966. See especially pages 52-56. More advanced references will be found in any up-to-date textbook on modulation methods, expecially material dealing with pulse-code-modulation (PCM).

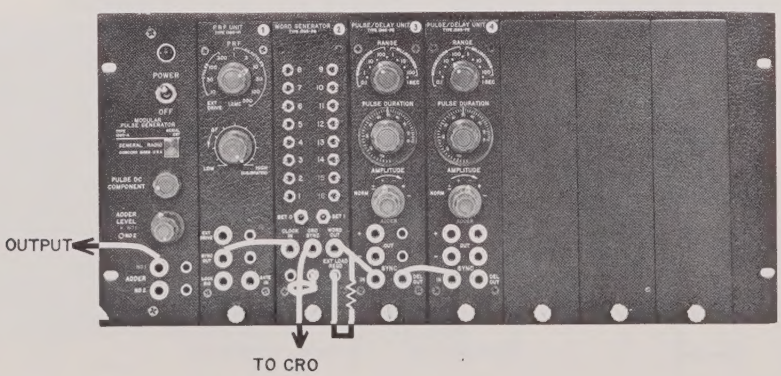


Figure 2-5. Interconnections for generating dipulse patterns.

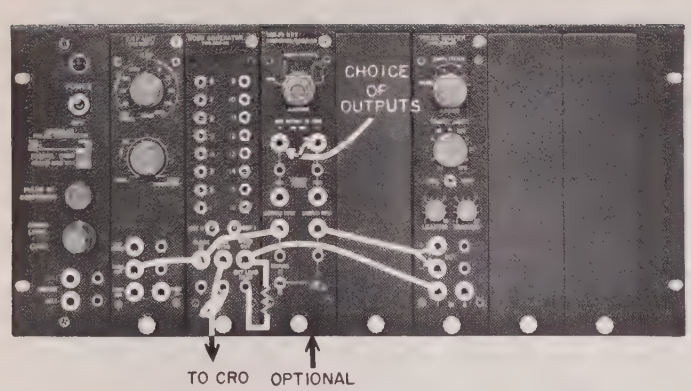


Figure 2-7. Connections for NRZI binary patterns.

change in state at the Pulse Shaper output terminals. NRZI is the result. However, the Pulse Shaper has no rise time shorter than 100 ns. If fast rise times are important in a given application, the output of the Shaper may be resampled by a Type 1395-P5 NRZ Converter/Sampler. The net effects are to delay the time of the final-pulse outputs by one pulse period and to shorten the rise time, provided the NRZ Converter/Sampler terminals are loaded by a low resistance, say 50 to 100 Ω. Since fast rise time is often not important, the Converter/Sampler in Figure 2-7 is marked "OPTIONAL."

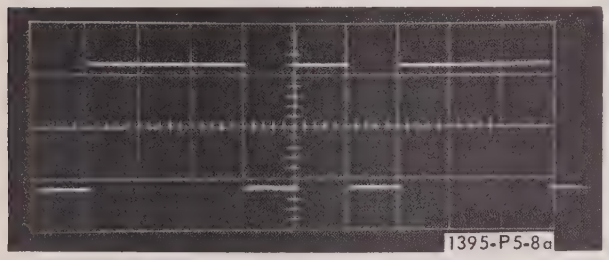


Figure 2-8a. An NRZI pattern, 11001111001.

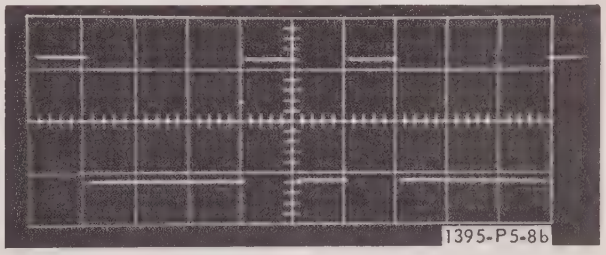


Figure 2-8b. The same NRZI pattern as Figure 2-8a, but reversed in polarity.

Note transitions are the same, however, and these carry the intelligence.

A sample of NRZI is shown in Figure 2-8a. Examine it carefully, unless you are already accustomed to this type of signal. The pattern is 11001111001. Note that the information is carried by transitions, not voltage levels. There is a transition at the left-most graticule line, hence a "1"; another transition at the second graticule line, and another "1"; at the third line from the left, there is no transition, and the binary signal consists of a "0"; and so on. Figure 2-8b shows exactly the same pattern reversed in polarity. The two figures should be compared until it is evident they are, in fact, the same pattern when judged on the basis of transitions.

Lastly, we consider diphase generation, which is the most complicated in terms of the equipment required. The interconnections are illustrated in Figure 2-9. Assume a 10-kHz bit rate (10 kilobauds). The desired choice of ONES and ZEROS is made as usual with a Type 1395-P6 Word Generator. The output of the Word Generator lags the CLOCK IN pulses by around 250 ns. Therefore, if the WORD OUT pulses are to be sampled to determine if a ONE or ZERO is present, the SAMPLING INPUT pulses in the Type 1395-P5 NRZ Converter/Sampler must be delayed so that they coincide in time with the SAMPLED INPUT pulses. This is the purpose of module 3, which is typically set for a delay of about 250 ns. Compare this with the technique in Figure 2-2. In Figure 2-2,

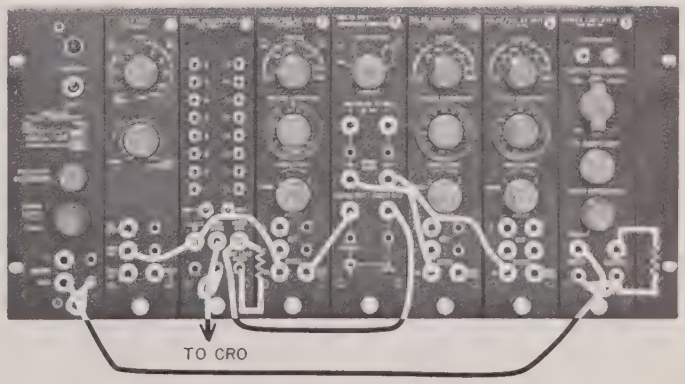


Figure 2-9. Interconnections for generating diphase binary patterns.

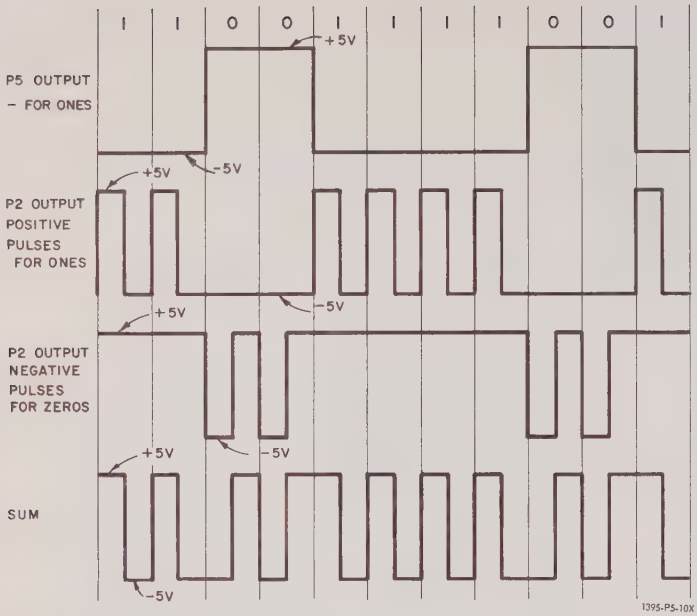


Figure 2-10. Construction of the diphase signal.

the need for an accurate time delay has been eliminated by sampling in the middle, more or less, of a relatively long pulse.

The outputs of the P5 unit, module 4 in Figure 2-9, are distributed as follows: The - FOR ONES voltage goes to the ADDER. Just for variety, ADDER NO. 2 is used this time. The ONES TRIGGER PULSES drive module 5, a Pulse/Delay Unit that gives a 50-μs pulse of positive polarity to ADDER NO. 2 for each ONE. Note the significance of the 50 μs: this time is one-half the period of the bit frequency, or half a baud. The ZEROS TRIGGER PULSES from the NRZ Converter/Sampler drive module 6, another Pulse/Delay Unit that sends negative 50-μs pulses to the ADDER NO. 2.

The Power Amplifier, Type 1395-P4, receives its input from the output of ADDER NO. 2. Diphase, like dipulse, involves no baseline shift, and is accurately reproduced by the Power Amplifier.

Figure 2-10 shows the assortment of signals produced in the set-up of Figure 2-9 and their sum. Brief study of this figure will convince the reader that results are as represented: the sum of these assorted signals is indeed diphase. To make addition easier and results obvious, the line marked "SUM" in Figure 2-10 omits the voltage attenuation that actually occurs in the resistive adder circuits and pretends the levels are still ±5 V. In reality, the voltage at the output of the adder will be a few tenths of a volt, peak-to-peak. An example of diphase is shown in Figure 2-11. The pulse sequence is 11001111001.

There are some small transients that do not show in Figure 2-10. These arise because the NRZ Converter/Sampler TRIGGER PULSES coincide in time with the NRZ transitions, but the outputs of the Pulse/Delay units lag about 60 ns after receiving the pulses on their SYNC IN terminals. Thus, between the end of the second baud and the start of the third in Figure 2-10, there will be a moment of time in the sum waveform when the voltage starts to rise in phase with the positive-going voltage of the P5 - FOR ONES output. The decreasing potential of the negative-pulses-for-zeros sketch has not really quite started when shown, but lags by 60 ns. As soon as this negative-going voltage does develop, it cancels the positive-going edge on the top line of Figure 2-10, and the sum is truly -5 V as sketched. The net result will be a tiny spike at the end of the second baud and start of the third. It cannot be seen in Figure 2-11. Figure 2-12 is an expanded-time-scale photograph, which does show the small spike between a ONE and a ZERO, about 1.6 major divisions from the left. There is also a spike between a ZERO and a ONE, caused by the

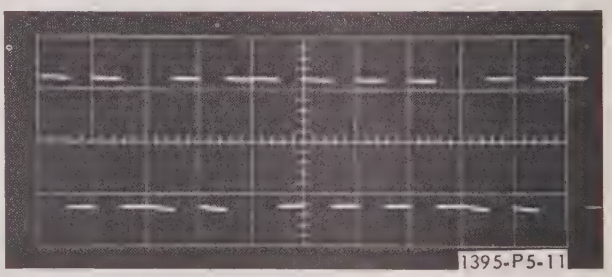


Figure 2-11. A diphase binary pattern, 11001111001.

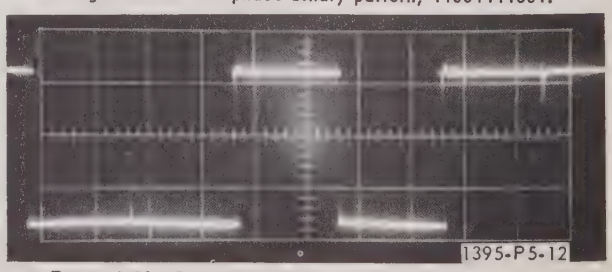


Figure 2-12. Detail of the transitions between ONES and ZEROS in diphase. The small spikes in particular are to be noted.

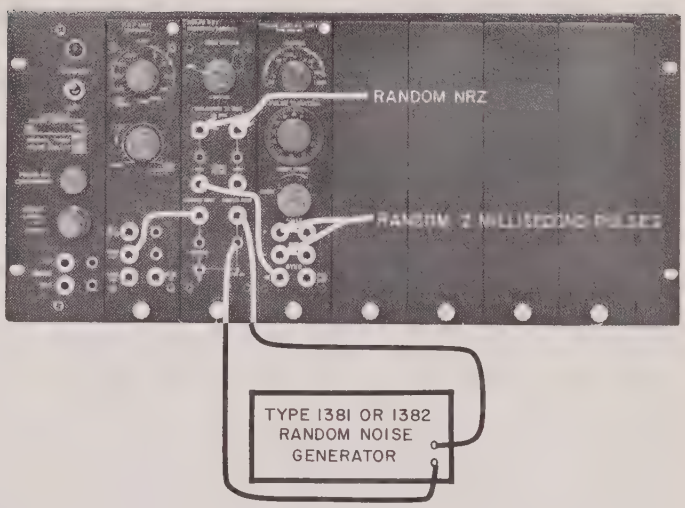


Figure 2-13. Random-pulse generation by noise sampling.

same time lag in starting the output of a P2 unit. This may be seen in Figure 2-12 about 9.5 major divisions from the left.

2.2.7 RANDOM PULSE TRAINS.

If random noise is sampled at a sampling rate much lower than the highest-frequency component in the noise, then the ONES and ZEROS found by the sampling action are random. The Type 1395-P5 NRZ Converter/Sampler is ideal for producing such random pulse trains.

Figure 2-13 shows how to connect the Type 1395-A Modular Pulse Generator to obtain a random pulse train. Note that the randomness is in terms of whether a pulse is a ONE or ZERO, not in terms of the moments in time when a pulse can occur.

Figure 2-14 shows a sequence of NRZ pulses obtained with the set-up of Figure 2-13. The figure is not really very informative by itself. It merely illustrates a pattern of pulses with no specially recognizable sequence, and that seldom remains in the same polarity for more than three or four bauds. This is to be expected, and indeed provides a good test of randomness.

Random signals produced by sampling noise with the Type 1395-P5 NRZ Converter/Sampler may be made as low in frequency as desired, simply by decreasing the bit rate at the SAMPLING INPUT terminal. This makes possible the generation of random sequences of pulses that may be used as noise sources for such things as servo motors, and that retain enough low-frequency content for the servos to respond. An example of this is given in Figure 2-15. This was taken by applying the NRZ + FOR ONES output directly to the input of an Esterline-Angus recording galvanometer. A piece of solder about five inches long was coiled around the pen arm to add mass and produce more mechanical integration than would have occurred otherwise. The chart speed was about 15 inches per minute. Note the effect of increasing the sampling rate.

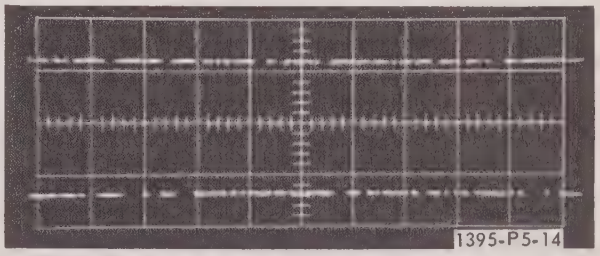


Figure 2-14. An example of a random NRZ pattern.

Other obvious applications of digital noise occur in testing computers, data transmission systems, and PCM telephone equipment. Once the random pulses (NRZ, trigger pulses for ONES, and trigger pulses for ZEROS) are obtained, they can be used to drive other 1395 modules. Thus, random sequences of di-

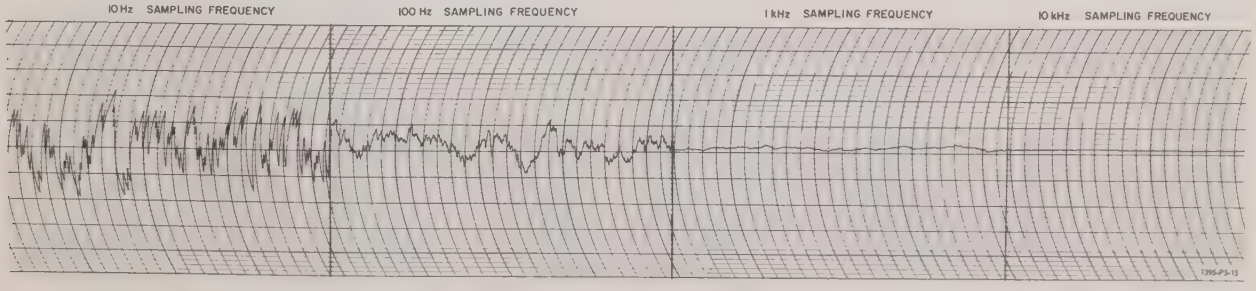


Figure 2-15. Pen motions produced by random NRZ signals.

phase, NRZI, or any other type of signal may be obtained readily.

2.2.8 GENERATING LOW-FREQUENCY NOISE*.

The discussion of Section 2.2.7 deals, generally speaking, with what might be considered a "coin-flipping" problem: i.e., the generation of a sequence of ONES and ZEROS in a random fashion. There may be cases when it is desirable to have the randomness represent a uniform energy density per cycle in order to achieve a low-frequency "white" noise. This problem has been treated in detail by Rice. We will assume that the sampling of noise by the method described in paragraph 2.2.7 results in obtaining a value at any given time, independent of the values at all other times. From this starting point, we continue with a quotation from Rice:

"Another type of random telegraph signal may be formed as follows: Divide the time scale into intervals of equal length h. In an interval selected at random the value of I(t) is independent of the value in the other intervals and is equally likely to be +a or -a. The correlation function of I(t) is zero for $|\tau| > b$ and is

$$a^2\left(1 - \frac{|\tau|}{b}\right)$$

for $0 \leq |\tau| < b$ and the power spectrum is

$$w(f) = 2b\left(\frac{a \sin \pi f b}{\pi f b}\right)^2 \qquad (2.7\text{-}9)"$$

Here I(t) represents the current or voltage from the NRZ + FOR ONES or NRZ - FOR ONES terminal. It is made random by virtue of sampling random noise, as described in paragraph 2.2.7 of this book. To fit Rice's notation, assume the PULSE DC COMP control on the main frame has been set so that the NRZ outputs are equally positive from and negative from zero volts during the ONE and ZERO intervals. Obviously, if this is not the case, we are merely introducing a dc offset into the power spectrum.

For convenience, let f_S be the sampling frequency. Then in Rice's equation 2.7-9 we may replace h by $1/f_S$. This gives

$$w(f) = \frac{2a^2}{f_S}\left(\frac{\sin\left(\frac{\pi f}{f_S}\right)}{\frac{\pi f}{f_S}}\right)^2$$

This is seen to be of the form

$$\left(\frac{\sin x}{x}\right)^2$$

The expression sin x/x is tabulated in many handbooks and compilations of tables. For this reason, it is a bit easier to use than the $(\sin x/x)^2$ function, and the net result of omitting the squaring is to examine the uniformity of a voltage or current spectrum rather than the power spectrum. Then, in terms of the voltage or current, the spectrum is white, i.e., equally strong at all frequencies, within 0.1 dB for $x \leqq 0.26$; within 1.0 dB for $x \leqq 0.82$; and within 3 dB for $x \leqq 1.38$.

Table 2.1 lists the frequencies for these various standards of "whiteness" as a function of the sampling frequency f_S.

Obviously, while the noise is white (to the degree of goodness selected from Table 2.1) clear down to dc, the amplitude will not have a Gaussian distribution. Only two amplitudes are possible: +a and -a, or these values with a dc offset introduced by the PULSE DC COMP control.

2.3 OPERATING TECHNIQUES.

2.3.1 COUPLING AND THRESHOLD CONTROLS.

The COUPLING switch and the THRESHOLD control are somewhat interrelated in their application, and so will be discussed together. Their purpose is identical to that of similar controls often found on electronic digital counters. Just as the controls on a counter should be set to reduce the possibility of incorrect counting (in a sense, incorrect sampling by the counter of the incoming waveform), so they should

*Rice, S. O., "Mathematical Analysis of Random Noise," BSTJ, Vol. 23, No. 3, pp. 282-332, July, 1944.

TABLE 2-1

FREQUENCIES AT AND BELOW WHICH NOISE IS WHITE WITHIN TOLERANCES LISTED

Sampling Frequency (Hz)	*Frequency in hertz equal to or less than* (0.1 dB)	(1.0 dB)	(3.0 dB)
1	0.083	0.261	0.440
3	0.249	0.783	1.32
10	0.83	2.61	4.40
30	2.49	7.83	13.2
100	8.3	26.1	44.0
300	24.9	78.3	132.0
1000	83.0	261.0	440.0
3000	249.0	783.0	1320.0
10000	830.0	2610.0	4400.0
30000	2490.0	7830.0	13200.0
100000	8300.0	26100.0	44000.0

be set on this module to minimize the possibility of incorrect sampling. The optimum adjustment is made much easier if one has some *a priori* knowledge of the signal to be sampled.

Figure 2-16 shows the voltage levels at the SAMPLED INPUT terminal that result in ONE and ZERO decisions. The separation between these lines is the hysteresis between ONE and ZERO levels seen by the SAMPLED INPUT terminal. If the input voltage is greater than, *i.e.*, lies above, the upper curve, the sampling action will conclude a ONE exists. If the input voltage is less than, *i.e.*, lies below, the lower curve, the sampling action will conclude a ZERO exists. Now, suppose the THRESHOLD ADJUST control is about 60% of the way clockwise from exact center and the SAMPLED INPUT signal is a sinewave with a superimposed dc bias voltage of 0.7 V. If the sinewave has a low amplitude, say 200 mV, p-p, the SAMPLED INPUT voltage will vacillate back and forth wholly within the area bounded by the curves in Figure 2-16. Neither switching level will be intersected, and the circuit will, for all practical purposes, never know a signal was applied at all. The ONE-ZERO decision will be made on the basis of the instrument's memory of the last unambiguous input voltage it received.

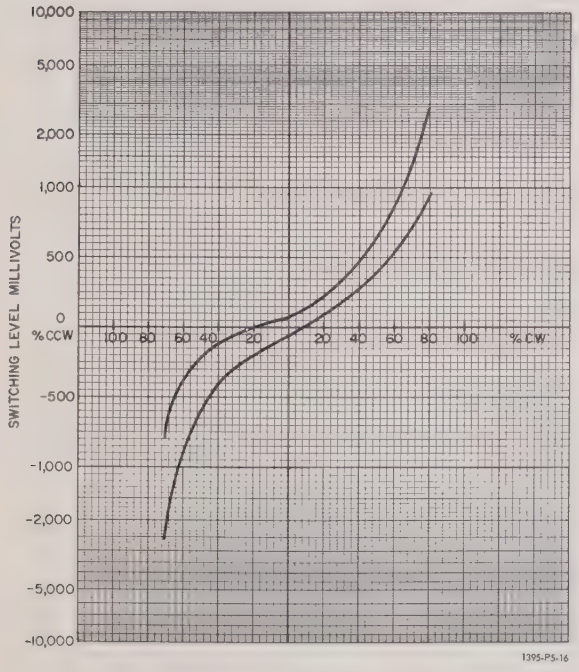


Figure 2-16. Typical switching levels versus THRES ADJ control settings.

What can be done about this? In the example of a weak sinewave with dc bias, simply switch the COUPLING switch to the AC position and set the THRES ADJ control to center. The bias is removed, and the 200-mV, p-p, signal will be enough to operate the instrument.

Consider another example. Say we want to sample a waveform that is roughly square, and alternates back and forth between ground and -1-V amplitude. Figure 2-16 shows that the THRES ADJ control could be set dead center, if the COUPLING switch is set to AC. We have already postulated that the signal to be sampled is roughly a square wave; therefore, passing it through an ac coupling will have the effect of shifting its limits to +0.5 and -0.5 V instead of 0 and -1.0 V. The boundaries of +0.5 and -0.5 are ideal for the centered THRES ADJ setting.

Suppose the task is to judge whether a noisy negative-going pulse is in the ONE or ZERO state. Since we are now dealing with a pulse, presumably the applied voltage is near ground potential almost all the time. Examine the pulse in Figure 2-17. Neglect, for the moment, the noise. If the signal were perfectly clean, and at the baseline 99% of the time, then the existence of the pulse for 1% of the time will have the effect of introducing a dc offset equal to 1% of the maximum amplitude, i.e., 0.01 V. If this were connected through the ac coupling by setting the COUPLING switch to AC, the voltage levels seen by the internal circuit would lie between +0.01 and -0.99 V. If the THRES ADJ control were set dead center, the upper boundary in Figure 2-16 would never be crossed. The THRES ADJ control must be set somewhat counterclockwise, say about 20%, for operation to occur.

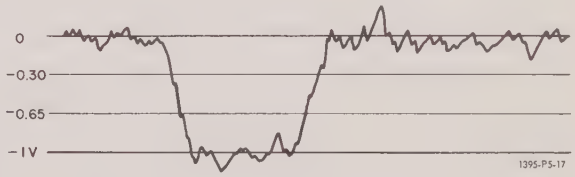


Figure 2-17. A noisy negative pulse.

2.3.2 NOISE COMPENSATION.

Now, let us take the noise into account. Noise spikes have the effect of restricting the portion of the pulse that is really meaningful for sample-taking. Figure 2-17 suggests we should confine our attention to voltages between about -0.15 and 0.85 V to avoid sampling on noise. Referring to Figure 2-16, we find that at about 52% rotation counterclockwise, the triggering levels are -0.3 and -0.65 V. If we set the THRES ADJ control to this position, nearly all the noise will fall outside the range of interest: it will either be too close to 0 volts to operate the switching circuits, or too close to -1 V. It will not matter whether the COUPLING switch is set to AC or DC in this case, because the offset is only 0.01 volts for a pulse with 1% duty cycle. Suppose now the pulse changes from a 1% duty cycle to a 40% duty cycle keeping its -1-V amplitude. If this were passed through an ac-coupled circuit, the upper voltage would be 0.4 V and the lower voltage -0.6 V. Figure 2-17 shows that if the THRES ADJ were left about 50% counterclockwise, the lower curve would be intersected only when the sampled pulse is given a boost in the negative direction by a noise spike. This is clearly

intolerable. We could fix this situation by moving the THRES ADJ control more clockwise. But a better idea in this case would be to use direct coupling, that is, to set the COUPLING switch to DC while the THRES ADJ is left about 50% counterclockwise. Then the duty cycle of the applied pulse would no longer matter. The noisy baseline would always be at 0 ± 0.15 V, and the noisy pulse would always be at -1 ±0.15 V.

Note the possibilities here of using the THRES ADJ control as an attenuator once it is set beyond about 60% rotation in either direction. Only relatively strong signals will then operate the internal sampling circuits, and noise immunity may be increased tremendously if an adequate input signal is present. There may be some difficulty in sampling a weak signal that is accompanied by dc offset voltage. Simply setting the COUPLING switch to AC will usually solve the problem.

2.3.3 SAMPLED INPUT VOLTAGE REQUIRED AS A FUNCTION OF FREQUENCY.

The specifications stating the adequacy of a SAMPLED voltage of 0.2 V peak-to-peak obviously will not apply to attempts to pass very low frequencies through a capacitor. In the ac coupled input mode, more and more voltage is required as the frequency drops. Figure 2-18 shows the trigger voltage as a function of frequency for one instrument picked at random. This figure does not represent a specification, or even an average, but should serve as a guide to probable performance.

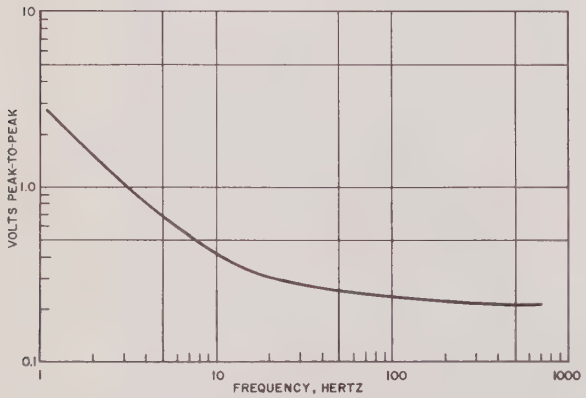


Figure 2-18. Voltage increase required at low frequencies when SAMPLED signal is ac coupled.

2.3.4 OUTPUTS.

2.3.4.1 Non-Return-to-Zero. These output jacks are mounted on the front panel of the NRZ Converter/Sampler Unit (3 and 9 in Figure 1-2). The level of the - FOR ONES jack normally is at a voltage V1 until an output pulse starts, and then it falls to a lower potential V2. The level of the + FOR ONES jack is normally at V2, and rises to V1 while a pulse is being generated.

Consider that behind each output terminal is a current source of 20 mA shunted by a 1-kΩ resistor. Therefore, the maximum open-circuit pulse voltage

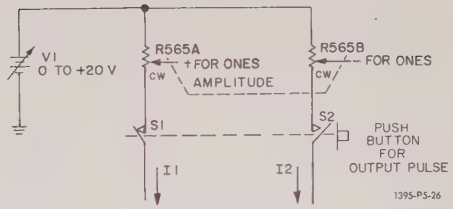


Figure 2-19. Conceptual circuit of the output stages of the Type 1395-P5 NRZ Converter/Sampler Unit.

is 20 V and the maximum short-circuit pulse current is 20 mA. Actually, some additional current is available so that a full 1-V pulse can be developed across 50-Ω loads shunted by the internal 1000 Ω. Both the + FOR ONES and the - FOR ONES terminals may be safely short-circuited for any length of time.

Figure 2-19 shows an approximate equivalent circuit of the NRZ output portion of the NRZ Converter/Sampler Unit. Disregarding the difficulty of open-circuited constant-current generators, imagine I1 and I2 to be flowing steadily. The IR drop in R565A causes the contact of S1 to be at a lower voltage than V1. This lower voltage is V2. There is no IR drop in R565B, so the contact of S2 is at V1. When the button is pushed, S1 rises to V1 and S2 drops to V2 since I1 = I2. The voltage V1 is adjusted by the PULSE DC COMPONENT control on the main frame of the Type 1395-A Modular Pulse Generator. As the AMPLITUDE control setting is varied, the amplitude of positive pulses changes by going from an adjustable baseline (the fraction of the I1 x R565A drop selected by the potentiometer) to a fixed upper boundary value V1. The amplitude of negative pulses changes by going from a fixed reference level V1 to whatever fraction of I2 x R565B is selected by the potentiometer.

Because negative pulses have a baseline voltage invariant with AMPLITUDE control settings, it is often easier to synthesize a multilevel pulse by adding negative rather than positive components.

2.3.4.2 Output Impedance. The output impedance at both the NON-RETURN-TO-ZERO jacks is a function of the AMPLITUDE control setting. With the AMPLITUDE control fully clockwise, the output impedance is 1000 Ω. The impedance decreases linearly as the AMPLITUDE control is turned counterclockwise, to 600 Ω at 60% of full amplitude, 250 Ω at 25% amplitude, etc.

2.3.4.3 Effect of Load Resistance. If the value of a resistor connected between a NRZ jack and ground is less than 10 or 20 kΩ, there will be some interaction between the adjustment of the PULSE DC COMPONENT control on the Type 1395-A main frame and the AMPLITUDE control on the Type 1395-P5 NRZ Converter/Sampler Unit.

For example, consider a 300-Ω load resistor with the PULSE DC COMPONENT equal to zero (i.e., the pulse rises from 0 V dc to a positive value). With full clockwise setting of the AMPLITUDE control, the maximum output voltage is determined by 20 mA flowing in 300 Ω shunted by the 1000-Ω internal resistance of the potentiometer. This voltage is about

4.6 V. In terms of the equivalent circuit of Figure 2-20, resistor R2 is zero and R1 is the full 1000 Ω of R565A. To obtain the zero-voltage baseline, the offset current I_O must equal the generator current I, a constant 20 mA. With the - FOR ONES jack at 0 V dc, the current I_O is simply V/R1, and since R1 = R565A in this example, V must be such that V/1000 Ω = 20 mA. Hence, V = 20 V, which is full clockwise setting on the PULSE DC COMPONENT control.

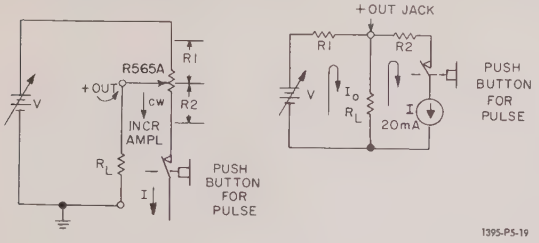


Figure 2-20. Load resistor connected to the positive output stage.

Now suppose we wish a half-amplitude pulse, or 2.3 V across R_L still with a 0-V dc baseline. The output pulse is generated when the switch is opened. Figure 2-21 gives the equivalent circuits for the baseline and output conditions. In part (a), the voltage at the + FOR ONES jack must be 0. Therefore, no current flows in R_L, and so the entire 20 mA must flow in R1. Then:

$$V/R1 = 0.02$$

When the output pulse is generated, part (b) of Figure 2-21 applies, and:

$$\frac{300\ V}{300 + R1} = 2.3$$

Solving equations (1) and (2) yields:

R1 = 187 Ω (AMPLITUDE control 81.3% of full rotation)
V = 3.74 V

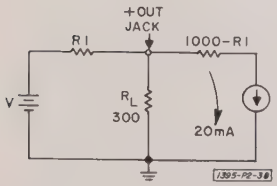


Figure 2-21a. Equivalent circuit for positive output stage with a low-resistance load at baseline conditions.

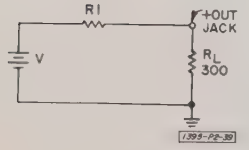


Figure 2-21b. Equivalent circuit for positive output stage with a low resistance load at output conditions.

Note that with low load resistance, there may be an appreciable difference between the setting of the AMPLITUDE control and the actual amplitude.

With the AMPLITUDE control set to a minimum, the load resistor is directly across voltage source V. To protect against the effects of a short circuit, the power supply symbolized by V is limited to about 150 mA. Any attempt to draw current beyond this value causes V to decrease.

In actual usage, setting the controls is not difficult. We recommend use of a cathode-ray oscilloscope. The oscilloscope must have direct-coupled input amplifiers to establish the dc baseline level of the NRZ output pulse.

2.3.4.4 Rise Time. The rise time of the output of the Type 1395-P5 NRZ Converter/Sampler Unit is determined by the load resistance and any capacitance, stray or otherwise, shunting the load. With a purely resistive load of 50 Ω and the AMPLITUDE control turned to maximum output (fully clockwise), all rise and fall times will be 15 ns or less.

With open-circuited NRZ jacks and the AMPLITUDE control fully clockwise, rise and fall times are typically about 80 ns, plus 2 ns per pF of external capacitance, and decrease as the AMPLITUDE control is rotated counterclockwise.

Remember that at very short rise times, many oscilloscopes lack sufficient bandwidth to show what happens. A true 10-ns rise time, viewed with an oscilloscope that has 10-ns rise time, will look like a 14-ns rise time.

2.3.5 THE TRIGGER PULSES OUTPUTS.

The TRIGGER PULSES are used to initiate the action of other modules, such as the 1395-P2 Pulse/Delay Unit and the 1395-P3 Pulse Shaper. These pulses are approximately 12 V in amplitude and 100 ns in duration. Unlike the Non-Return-to-Zero outputs, which change state only if the SAMPLED INPUT level changes its state, the TRIGGER PULSE outputs give a pulse each time a SAMPLING INPUT pulse is applied. If the SAMPLED INPUT at that moment is in the ONE state, the TRIGGER PULSE will be at the ONES TRIGGER PULSE terminal. If the SAMPLED INPUT is in the ZERO state, the TRIGGER PULSE will be at the ZEROS TRIGGER PULSE terminal. Figure 2-9 showed one example of the use of the TRIGGER OUTPUT pulses.

Another example is the analysis of an input signal to determine the relative amounts of time it is in the ONE and ZERO states. Simply connect the ONES TRIGGER PULSES and the ZEROS TRIGGER PULSES to two separate counting devices, such as the General Radio Type 1191 Counter. Apply sampling pulses at a rate higher than the highest frequency component expected in the SAMPLED INPUT signal, and the two counters will show the number of times a ONE is found, and the number of times a ZERO. The ratio of the displayed numbers will be proportional to the time the incoming signal was in each state.

2.3.6 ADDERS.

2.3.6.1 General. The Type 1395-A Modular Pulse Generator main frame contains two adder bus bars. The ADDER switch on the front panel of the NRZ Converter/Sampler selects which output (+ FOR ONES or - FOR ONES) will be connected to which adder bus.

Red plus and minus symbols represent connection to ADDER NO. 1 and white symbols represent connection to ADDER NO. 2. The ADDER switch position marked with both a red + and a white - simultaneously sends a portion of the + OUT to ADDER NO. 1 and a portion of the - OUT to ADDER NO. 2.

Figure 2-22 is a simplified sketch of the adder system. To begin with, imagine that the prime and double-prime units are not plugged in. The tap of R565 (either A or B) connects to the OUT terminal and to a 1-kΩ resistor. If S is closed, the 1-kΩ resistor is connected to an adder bus. Now suppose that R565 is set fully clockwise for maximum amplitude. The total load resistance is then R565 shunted by the sum of R566 and the 100-Ω adder potentiometer (1000 Ω in parallel with 1100 Ω). This resistance is about 525 Ω, and the maximum open-circuit output voltage is 10.5 V compared to 20 V with the adder disconnected. One eleventh (100 Ω − 1100 Ω) of this open-circuit voltage appears at the top of the adder potentiometer (about 0.95 V). Note that this is an attenuation of about 26.5 dB compared with the open-circuit voltage at the NRZ jack with S in the NORM (open) position. To obtain lower voltages at the adder output terminals, turn the ADDER LEVEL controls on the main frame counterclockwise.

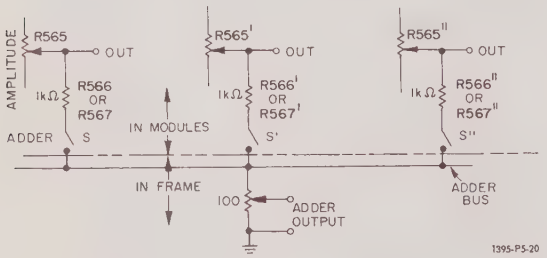


Figure 2-22. The outputs of three Type 1395-P5 NRZ Converter/Sampler Units connected to an adder bus in the Type 1398-A main frame.

When several Pulse/Delay Units are connected to the adder bus (switches S' and S'' in Figure 22 are closed, for example), a certain amount of crosstalk is present among the output terminals. For example, a small part of the current going through R566 will go up through R566' and appear at the output terminal at the tap of R565'. Therefore, when the adders are in use, connections should not be made simultaneously to the regular NRZ jacks. No harm is done, but the results may be confusing. Also, any variation in load resistance at an NRZ jack that is also connected to an adder varies the current going from the Pulse/Delay Unit to the adder, and this will change the pulse at the ADDER jack.

The Type 1395-P2 Pulse/Delay Unit and the Type 1395-P3 Pulse Shaper have adder circuits identical to those in the NRZ portion of the Type 1395-P5 NRZ Converter/Sampler. If Pulse/Delay Units, Pulse Shapers, and the NRZ Converter/Samplers are used in additive connections, the examples and instructions just given apply equally (except for component part numbers) to all three types of modules.

2.3.6.2 External Adder Inputs. Terminals on the rear panel of the Type 1395-A Modular Pulse Generator provide additional connections to the adder busses. Signals that are not generated by any of the standard 1395 Series modules can be injected at these terminals. For example, to investigate the effects of noisy pulses, the output of a General Radio Type 1381 or 1382 Random-Noise Generator can be combined with the NRZ output of a Type 1395-P5 NRZ Converter/Sampler. The NRZ Converter/Sampler Unit is switched to the desired ADDER setting and the Random-Noise Generator is connected to the adder via the rear panel.

2.3.6.3 Type 1395-P4 Power Amplifier. The Type 1395-P4 Power Amplifier is recommended to increase the signal level from the adder output. This amplifier has rise and fall times no greater than 60 ns (typically about 40 to 45 ns) with 50-Ω loads and ramp-off no greater than 10% in 1.5 ms. The voltage gain is 10 X with 50-Ω and 93-Ω output impedance, and 20 X with a 600-Ω output impedance. The possibility that ramp-off will be a significant problem must be borne in mind when NRZ is involved.

2.3.7 A NOTE ON TIME DELAYS.

In any system involving driving one pulse source from another, time delays will occur between the driving pulse and the output. In the configuration involving a Word Generator and an NRZ Converter/Sampler, such delays occur in both the Word Generator and the Converter. The WORD OUT pulses from a Word Generator occur about 250 ns after the CLOCK IN pulses. The TRIGGER PULSES and the leading edges of the NON-RETURN-TO-ZERO pulses occur about 190 ns after the SAMPLING INPUT pulses.

Figure 2-23 shows the pulses of importance in their time relationships to one another. The horizontal scale is 100 ns per major division. The top line, A, is the master clock pulse from a Type 1395-P1 PRF Unit. (Refer to Figure 2-9.) Line B shows the output of a Type 1395-P6 Word Generator, set to generate a ONE. Line C shows a SAMPLING INPUT pulse delayed just enough by another Pulse/Delay Unit so that it will sample the pulse on line B correctly. Finally, the bottom line, D, shows the output of the ONES TRIGGER PULSES jack. The total delay is about 500 ns. This may or may not matter. If it is necessary to have a clock pulse coinciding with the TRIGGER PULSE outputs, then the original clock pulses may be delayed with still another 1395-P2 Pulse/Delay Unit until the DEL OUT jack of this module gives an output coinciding with the TRIGGER PULSES outputs of the NRZ Converter/Sampler Unit.

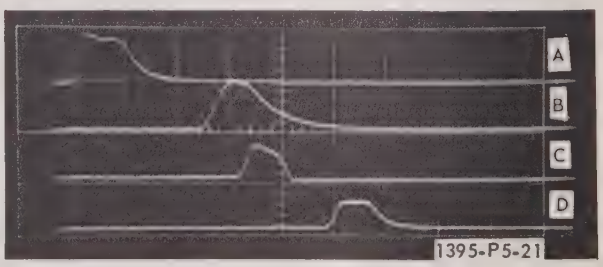


Figure 2-23. Cumulative delays in passing from one module to another. Time scale: one major division = 100 ns.

SECTION 3

PRINCIPLES OF OPERATION

3.1 GENERAL.

The block diagram of Figure 3-1 shows the sequence of operations within this module. The INPUTS block (Q501, Q505, Q506, Q507) consists of a limiter and a buffer. The limiter turns the signal at the SAMPLED INPUT into a rectangular waveform with the fastest practical rise and fall times. The limiter output will be in the ONE or ZERO state, depending on the level of the SAMPLED signal and the setting of the THRES ADJ control. The buffer isolates the SAMPLING INPUT terminal from the internal circuits.

In the FIRST SAMPLER (Q502, Q503, Q504) the rectangular signal from the limiter is first examined to see if the level at the SAMPLED input is ONE or ZERO. However, at this stage in the instrument, an ambiguous decision is possible if the SAMPLING INPUT is triggered just as the SAMPLED INPUT goes through a change of state. Then the output of the first sampler can indicate both ONE and ZERO simultaneously.

When an ambiguous situation exists, some decision is better than none. Therefore, we allow the outputs of the first sampler to go to a flip-flop (Q508, Q509), marked STORE in Figure 3-1. If this is pulsed with a ONE and a ZERO command simultaneously, it will be a matter of luck which state it settles into, but it will settle into one or the other. We must allow it time enough to do so. For this reason, delay is provided in the block diagram to prevent examining the

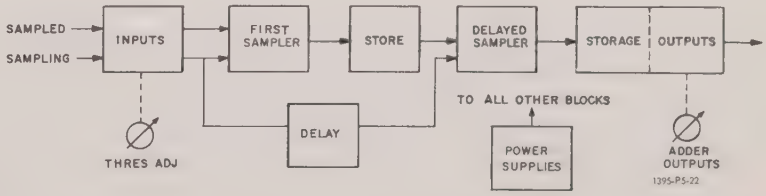


Figure 3-1. Block diagram of the NRZ Converter/Sampler.

state of the store flip-flop too soon. After this delay, which is about 150 ns, the contents of the store flip-flop are examined. This is done in the DELAYED SAMPLER (Q510, Q511, Q512). The ONE-ZERO decision made at this time is stored in another flip-flop (Q560, Q562) which is intimately interconnected with the NRZ output amplifier circuits (V501, V502). At the same time, the pulse that told the output storage which state to take is amplified (Q562, Q563) and appears on the appropriate terminal of the TRIGGER PULSES jacks. The NRZ output signal is connected to the + FOR ONES and - FOR ONES jacks, and, via the ADDER OUTPUTS switch, to either, both, or none or the adder circuits in the Type 1395-A

3.2 THE SAMPLERS.

We will assume the reader is familiar with flip-flops, or if not, that he has access to some book on pulse circuits. Therefore, we will not discuss the storage elements of the module, but consider only the samplers here.

Figure 3-2 shows the delayed sampler. The first sampler is the same in principle. We will touch on the difference in a moment.

Because this is the delayed sampler, at the moment a pulse arrives at the base of Q512, the bases of Q519 and Q511 are at known "settled-down" voltages. One base will be at a higher potential than the other. This potential difference is several volts, decisive and unambiguous. When the base of Q512 is driven in a positive direction, Q512 tries to conduct. But it is able to do so only by drawing current through

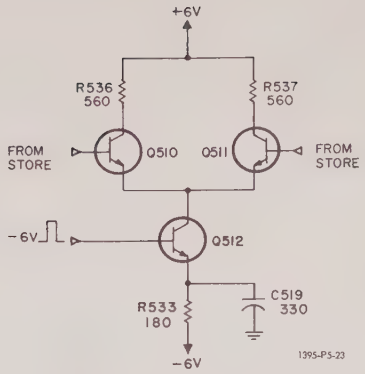


Figure 3-2. The STORE circuit section of the NRZ Converter/Sampler.

Q510 or Q511 also. Whichever of these two does conduct is determined by their base voltages. Therefore, a pulse can appear across one, and only one of the two resistors R536 and R537, representing ONES and ZEROS respectively. Note also that a pulse must appear. "No decision" is not an option.

The first sampler works in the same way, except that there is no resistor *per se* in the emitter circuit of Q504. Instead, the impedance in the emitter is the input impedance to a delay line. This delay line provides the delay shown in the block diagram of Figure 3-1. The complete schematic diagram of the Type 1395-P5 is shown in Figure 4-4.

SECTION **4**

SERVICE AND MAINTENANCE

4.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE..

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by the use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest sales engineering office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 TROUBLE-SHOOTING.

4.3.1 PASSING THE BUCK.

The Type 1395-P5 NRZ Converter/Sampler responds only to signals applied to its inputs. It is not a pulse generator in its own right. Therefore, if it fails to operate, first be sure that input signals of the proper amplitude, duration, and polarity have been applied to the correct terminals. If a spare module is available, it is helpful to swap one for the other as a means of determining whether the module is at fault or the drive signals inadequate. Be sure the THRES ADJ control is not set so far from center as to prevent operation completely (see Figure 2-16 regarding this). It may also be helpful to check the Type 1395-A Modular Pulse Generator as described in paragraph 4.3.2.

4.3.2 TROUBLE-SHOOTING IN THE TYPE 1395-A.

Make sure that the Type 1395-A Modular Pulse Generator is turned on, and that the power-line voltage and frequency are correct. Be sure that the Type 1395-A Generator is wired properly for the applied voltage. Check the fuses in the Type 1395-A.

Check the voltages at the connectors on the Type 1395-A, especially at the connector to which the NRZ Converter/Sampler Unit is attached. Connector voltages are listed in Table 4-1.

4.3.3 TROUBLE-SHOOTING THE NRZ UNIT.

Remove all the plug-in modules from the 1395-A Modular Pulse Generator. Look through the front of the generator toward the fan at the rear. To the right of the fan is an extension cord for connection of a module outside the Type 1395-A Generator. Remove this cord and use it to join the Type 1395-P5 NRZ Converter/Sampler Unit to any convenient connector on the Type 1395-A Generator. Turn the POWER switch on.

WARNING

There are high voltages present at several points in the Type 1395-P5. Exercise caution when making measurements to avoid personal injury. Always turn the power OFF before removing or inserting components.

TABLE 4-1
CONNECTOR VOLTAGES ON THE GENERATOR

Pin	*Voltage*	*Procedure When Voltage Is Incorrect*
1	+150	The +150-V level depends on the -150-V supply. First check the -150-V level at pin 2 (see below). When the -150-V level is correct, adjust the +150-V level with R536. If this does not correct the level, check tubes V501 and V503.
2	-150	Adjust R525. If this does not correct the -150-V level, check tubes V502, V505, V506, and V507.
3	Not Applicable	
4	Not Applicable	
5		Turn the ADDER controls on all modules to NORM. Set ADDER LEVEL NO. 2 fully clockwise. Measure the resistance between pin 5 and the ADDER NO. 2 output terminal with an ohmmeter. If this resistance is higher than 5 ohms, check for broken wires between the plug and printed board or a defective ADDER LEVEL NO. 2 potentiometer.
6, 13	6.3 V, 60 c/s, at -75 V dc	Check fuses. If the dc level differs by more than about 10% from -75 volts, suspect a cathode-filament short in V505 or V506, or one of the plug-ins.
7, 14	6.3 V, 60 c/s, at +50 V dc	Check fuses. If the dc level differs by more than about 10% from +50 volts, suspect a cathode-filament short in one of the plug-ins.
8	+15	This supply is not regulated and cannot furnish much current. A voltage between 12 and 18 volts is OK. If the voltage is less than 12 volts, look for excessive current in one of the modules. If a Pulse/Delay Unit is suspected, look for a shorted CR210.
9	Ground	Check continuity with an ohmmeter. If the resistance between pin 9 and chassis is more than 1 ohm, look for broken wires or cold solder joints.
10	0 to +20 V dc, variable	Turn the PULSE DC COMPONENT control back and forth. Voltage on pin 10 must vary at least from 0 to +20 volts, and will probably vary from -2 or -3 volts to +22 or more volts. If performance falls short of a variation from 0 to +20 volts, check V504 and Q501.
11	Not Applicable	
12		Turn the ADDER controls on all modules to NORM. Set the ADDER LEVEL NO. 1 fully clockwise. Measure the resistance between pin 12 and ADDER NO. 1 output terminal with an ohmmeter. If this resistance is greater than 5 ohms, check for broken wires between plug and printed board or defective ADDER LEVEL NO. 1 potentiometer.

Check visually to be sure that all filaments in the tubes glow. These tubes are dual triodes; four separate filaments should be visible. Replace any dead tubes.

4.3.3.1 Power Supply Troubles. With a dc voltmeter, check the voltages at the power supply of the Type 1395-P5. Although the circuit diagram speaks of them as +6 and -6 V, it is better to set them to about +6.5 and -6.0 V. If either of these voltages should be zero, or very low, proceed as follows. Refer to the schematic diagram, Figure 4-4. For zero volts on one power supply but not both, either there is a dead short to ground or a regulator transistor Q550 or Q552 is out of service. If a short is suspected, turn off the power and check resistance to ground with an ohmmeter. If this test verifies the existence of a short, inspect the etched boards carefully, looking for foreign material such as metal chips, solder balls, etc. If any material is removed as a result of this inspection, check the resistance with the ohmmeter again to be sure the fault is cleared. If the short still exists, unsolder the connections at AT507A and AT506A. This separates the two etched boards from one another, and makes it easier to locate the trouble. From this point on, there is not much to do but make the best possible guess as to its location, and unsolder components until the defective one is removed. If the zero voltage condition is caused by an open-circuited transistor, Q550 or Q552, an ohmmeter check to ground from the +6 or -6-V supply will show normal resistance. This is about 1100 Ω for the +6-V supply and 1000 Ω for the -6-V supply. This measurement puts the finger of guilt on the power supply itself, and the defective transistor must be replaced. If both power supplies have zero output voltage, then the difficulty is probably a broken lead where a brown or red wire joins the socket of V502.

If power supply voltages are abnormally high, the positive being significantly greater than about 6.5 V or the negative being significantly more negative than about -6.0 V, the most likely trouble is in Q551 or Q553 respectively. After the power-supply overvoltage is corrected, check the module to be sure no other damage occurred as a consequence of the excess voltage.

4.3.3.2 No Output from Any Terminal. Probably there is no internal signal reaching any of the output stages. This almost certainly means the difficulty is to the left of an imaginary line joining AT501 and AT502 on the circuit diagram. It further almost guarantees trouble in the path from Q501 through Q504 through Q512. If the trouble were in the input limiter, for example, there should be at least all ONES trigger pulses or all ZEROS trigger pulses. Damage to Q501 is most probable, since this is in a relatively vulnerable position as one interface to signals external to the module. Figure 4-1 shows the waveforms at the emitters of Q501, Q504, and Q512, respectively. These were obtained with a 300-kHz clock pulse from a 1395-P1 PRF Unit driving the SAMPLING INPUT terminal. The signal at the emitter of Q504 will vary slightly in amplitude depending on whether the SAMPLED INPUT voltage corresponds to a ONE or a ZERO, but the difference is small and in no way alters the general appearance of Figure 4-1b.

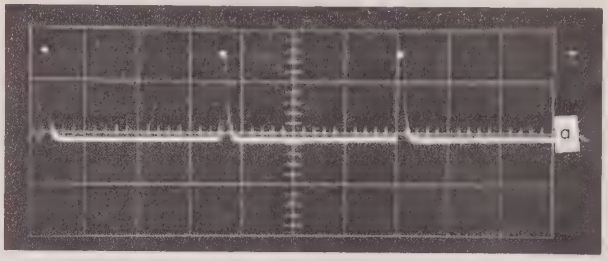


Figure 4-1a. Waveform at the emitter of Q501. Vert: 10 V/div, Horiz: 1 ms/div.

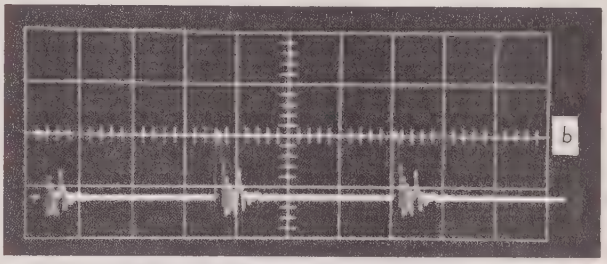


Figure 4-1b. Waveform at the emitter of Q504. Vert: 5 V/div, Horiz: 1 ms/div.

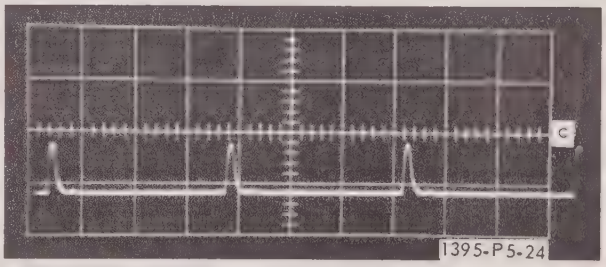


Figure 4-1c. Waveform at the emitter of Q512. Vert: 5 V/div, Horiz: 1 ms/div.

Conditions for Figure 4-1: Signal to SAMPLING INPUT terminal from Type 1395-P1 PRF Unit at a 300-kHz rate. In all cases, "ground" is exactly center from top to bottom of the graticule.

4.3.3.3 No Output from ONES TRIGGER OUTPUT Terminal. If the other outputs occur normally, the most probable trouble is a defective Q562. Try replacing this transistor. If this does not cure the trouble, the next most probable difficulty is a shorted CR566, CR567, or CR564.

4.3.3.4 No Output from ZEROS TRIGGER OUTPUT Terminal. If the other outputs occur normally, the most probable trouble is a defective Q563. Try replacing this transistor. If this does not cure the trouble, the next most probable difficulty is a shorted CR570, CR571, or CR568.

4.3.3.5 No Output from NRZ Terminals. If TRIGGER PULSES are generated correctly, and there is no output from the NRZ terminals, the tubes may be defective even though the filaments light. Test the tubes. If the tubes are OK, the next most likely trouble is the set-reset flip-flop involving Q560 and Q561. Apply a simple signal, such as a sinewave or a square wave, to the SAMPLED INPUT, and sample this signal with a sampling frequency that is much higher (e.g., samplED signal of 1 kHz, samplING signal of 100 kHz). There should be a square wave, or something very close to square, at the collectors of Q560 and Q561. If not, these transistors are almost surely the root of the trouble. BE SURE TO CHECK THE TUBES FIRST. The current for these transistors flows through the tubes, so if the tubes are not good, or if they are out of their sockets, examination of the waveform at the transistors will be not only pointless, but downright misleading.

4.3.3.6 Output Consists of Only ZEROS or Only ONES, Both on NRZ and on TRIGGER OUTPUTS. There are three probable causes of this trouble: a sampling-circuit defect, a storage circuit defect, or trouble at the limiter circuit that follows the SAMPLED INPUT terminal.

(1) Sampling-circuit defects. There are numerous possibilities, all involving open or shorted transistors Q502, Q503, Q510, and Q511. The best way to track this down is to look at the collectors of these four transistors with an oscilloscope. At the point where trouble starts, you will see an uninterrupted sequence of negative pulses, one for each time the SAMPLING INPUT is pulsed. This will locate the defective sampler. You will probably save time by replacing both transistors in the Q502-Q503 pair or the Q510-Q511 pair right away. This will be easier, generally speaking, than trying to decide if one transistor is shorted or the other one is open-circuited.

(2) Storage-circuit defects. These are revealed by the refusal of a storage flip-flop to change state. If flip-flop Q560-Q561 were the guilty one, then the trouble would look like the case already covered in paragraph 4.3.3.5 dealing with no output from the NRZ terminals. Therefore, we can assume flip-flop Q508-Q509 is in trouble. Again, it is probably quicker to replace both transistors than to determine which of the two is defective. If the trouble persists, check CR508-CR509 and then capacitors C514-C515.

(3) Trouble at the limiter circuit could just possibly be a grossly misadjusted THRES ADJ control. Be sure, for trouble-shooting purposes, that this control is approximately midway between its clockwise and counterclockwise extremes. Apply a signal of several volts, rms, (preferably a square wave but a sinewave will do), to the SAMPLED INPUT terminal. The frequency may be any convenient value; we suggest 10 kHz to 100 kHz. Observe the signal at the base of Q507A. There should be some sort of square wave here. The exact amplitude will depend on the THRES ADJ setting, but 0.5 to 1.0 V, p-p, could be considered normal. If this square wave is missing, the most probable trouble is a shorted diode, either CR502 or CR503.

Next check the collectors of Q507A and Q507B. (This transistor differs from most in that the metal locating stud on the bottom of the case is near the collectors, not the emitters.) There should be approximately square waves on each collector. The amplitude and dc-baseline levels vary with the THRES ADJ setting, but 1 to 2 V, p-p, would be within normal ranges. If the collectors do not have square waves, replace Q507.

If all is well as far as the collectors of Q507, then check the collectors of Q505 and Q506. Each of these collectors should exhibit an essentially square wave on an oscilloscope. If one of them does not, then the corresponding transistor must be replaced.

4.4 NORMAL ADJUSTMENTS AND CALIBRATION.

Only two adjustments are possible in the Type 1395-P5 NRZ Converter/Sampler. These are the settings for the power-supply voltages.

Connect a dc voltmeter between anchor terminal AT507A and ground, positive side of the meter on AT507A. Adjust potentiometer R551 until the meter indicates 6.5 V.

Table 4-2 lists the voltages associated with the various tubes and transistors of the Type 1395-P5. The values listed should be regarded as guides to correct voltage levels, rather than as go-no-go tests.

4.5 MINIMUM PERFORMANCE STANDARDS.

NOTE

This procedure assumes that the Type 1395-A (main frame) is functioning properly in accordance with its own minimum performance standard.

4.5.1 POWER CONSUMPTION.

The following procedure checks the power consumption of the NRZ Converter/Sampler to be within specified limits.

a. Connect the Type 1395-A to an ac power line via the metered Variac and turn the Type 1395-A on.

b. Advance the Variac output to 115 V while observing the wattmeter. After thirty seconds a relay will close and the power consumption will increase. Note the wattmeter readings before and after the relay closes.

c. Turn off the Type 1395-A and insert the Type 1395-P5 into the main frame.

d. Turn the Type 1395-A on. The power consumption before the relay closes must be 112 W ±10%. The power consumption after the relay closes must be 155 W ±10%.

4.5.2 INPUT IMPEDANCE.

The input impedances of the Type 1395-P5 are determined to be specified as follows:

a. Connect an ohmmeter between the SAMPLED INPUT terminal and chassis ground. Set the INPUT

TABLE 4-2
DC VOLTAGES TO GROUND*

Transistors	*Emitter*	*Base*	*Connector*	*Tubes*		
				Pin Number	*V501*	*V502*
Q501	- 0.2	+ 0.3	①			
Q502	0	0	+ 6.5			
Q503	0	- 1.0	+ 6.5	1	- 34	- 20
Q504	- 6.5	- 6.5	0	2	-130	-136
Q505	+ 0.1	+ 0.9	+ 2.1	3	-129	-129
Q506	+ 0.1	- 0.5	+ 6.1	4⑤	- 74③	- 74③
Q507A	- 0.7	- 0.1	+ 0.9	5⑤	- 74③	- 74③
Q507B	- 0.7	- 0.1	- 0.4	6	- 34	- 20
Q508	- 1.4	- 0.6	- 1.3	7	- 33	- 33
Q509	- 1.4	- 2.7	+ 3.4	8	- 74③	- 74③
Q510	+ 0.5	- 2.5	+ 6.5	9⑤	- 5④	+ 22④
Q511	+ 0.5	+ 1.1	+ 6.5			
Q512	- 6.5	- 6.5	+ 0.5			
Q550	+ 6.5	+ 7.2	+12.7			
Q551	+ 2.9	+ 3.7	+ 7.2			
Q552	- 6.5	- 7.2	-12.7			
Q553	- 3.2	- 3.9	- 7.2			
Q560	+13.5②	+13 ②	+19.2②			
Q561	+13.5②	+14.3②	+13.8②			
Q562	+ 6.5	+ 6.5	- 6.5			
Q563	+ 6.5	+ 6.5	- 6.5			

*Measured with a dc voltmeter, 20,000 Ω/V.

Measurement Conditions:

SAMPLED INPUT terminals shorted.
SAMPLING INPUT terminal pulsed at a 100-Hz rate from a Type 1395-P1 PRF Unit.
All output terminals open.
THRES ADJ . . . fully cw
ADDED OUTPUTS . . . NORM
AMPLITUDE . . . fully ccw
PULSE DC COMPONENT
(Type 1395-A) . . . fully cw

Notes:

1 12 to 18 V normal range
2 Voltage above the -150-V power-supply bus
3 -65 to -85 V ok
4 Varies with setting of Type 1395-A PULSE DC COMPONENT
5 On both tubes, 6.0 Vac between pin 8 and pins 4 and 5

TABLE 4-3
EQUIPMENT REQUIRED FOR MINIMUM-PERFORMANCE TESTING

Equipment	*Specifications*	*Recommended Equipment* *
AC power source	0 to 125 V, variable with wattmeter	GR Type W5MT3W Metered Variac Autotransformer
Modular Pulse Generator (main frame)	(no substitution)	GR Type 1395-A
Pulse Generator	Capable of producing 10- to 20-V pulses into 5 kΩ with durations between 75 and 150 ns	GR Type 1395-P1 PRF Unit
High-frequency sinewave source	Frequency range from 500 kHz to 5.0 MHz, output amplitude at least 20 V, rms, into 5 kΩ	GR Type 1211-C Unit Oscillator with Type 1201 or 1267 Unit Power Supply
Variable pulse-delay unit	Capable of delaying pulses by intervals from 100 ns to 1 s long	GR Type 1395-P2 Pulse/Delay
Source of variable return-to-zero binary pulse patterns	Capable of producing binary patterns of 0.2-V, p-p, pulses at frequencies to 2.5 MHz, pulse duration variable	GR Type 1395-P6 Word Generator Type 1395-P1 PRF Unit for frequencies to 1.2 MHz, sinewave signal source above for frequencies to 2.5 MHZ
Oscilloscope	Bandwidth of at least 20 MHz, calibrated (ac and dc) vertical amplifier, calibrated sweep rates, dual trace	Tektronix Type 543 Oscilloscope with Type 1A2 Plug-In Unit and Type P6006 10X Probes (2)
Voltmeter/Ohmmeter	Capable of measuring up to 100 kΩ with ±10% accuracy	GR Type 1806 Electronic Voltmeter
Resistor	10 Ω ±10%, 1/2 W	—
Resistor	50 Ω ±5%, 25 mW	—
Resistor	820 Ω ±10%, 1/2 W	—
Patch Cord	Double banana plug to BNC	Tektronix 50-Ω Cable, part number 012-057 with Tektronix Adaptor, part number 013-076
Patch Cord	GR874 to double banana plug	GR Type 874-R33 Patch Cord
Patch Cord	Double banana plug to double banana plug	GR Type 274-NPS Double-Plug Patch Cord
Plug (2)	Double banana, with clamps on each plug end	GR Type 274-MB Insulated Double Plug

* Suitable substitutions may be made, except where noted.

COUPLING switch to DC. The meter should register 100 kΩ ±10%.

b. Set the INPUT COUPLING switch to AC. The ohmmeter should read ∞.

c. Connect the ohmmeter between the SAMPLING INPUT terminal and chassis ground. The ohmmeter should read 4.5 kΩ ±10%.

4.5.3 NRZ OUTPUTS.

The following procedures test the NRZ outputs of the Type 1395-P5 against their listed characteristics.

Set up.

a. With the Type 1395-A off, insert into it a Type 1395-P1 PRF Unit, two Type 1395-P2 Pulse/Delay Units, and a Type 1395-P6 Word Generator with the rear switches set: LOOP, 16, and OFF. (The Type 1395-P5 is already in the main frame.)

b. Make the following connections (Figure 4-2):

PRF Unit SYNC OUT to Pulse/Delay Unit #1 SYNC IN PRF Unit SYNC OUT to Word Generator CLOCK IN 820 Ω resistor (mounted on GR 274-MB) across Word Generator WORD OUT terminals.
Word Generator WORD OUT (high terminal) to Pulse/Delay Unit #2 SYNC IN
10-Ω resistor (mounted on GR 274-NPS) across Pulse/Delay Unit #2 + OUT terminals
Pulse/Delay Unit #2 + OUT terminals to Converter/Sampler SAMPLED INPUT terminals
Word Generator CRO SYNC to Oscilloscope EXT TRIGGER
Oscilloscope CH 1 Input Probe to NRZ + FOR ONES
Oscilloscope CH 2 Input Probe to NRZ - FOR ONES

c. Set the following controls:

PRF Unit PRF 100 KILOCYCLES
ΔF HIGH (CALIBRATED)
Pulse/Delay Unit #1 RANGE 0.1 · 1 MICROSECONDS
PULSE DURATION 50; ADDER NORM
AMPLITUDE fully counterclockwise
Pulse/Delay Unit #2 RANGE 1 · 10 MICROSECONDS
PULSE DURATION 50; ADDER NORM
AMPLITUDE fully clockwise
Word Generator 1, 3, 4, 6, 7, 8 on (switch towards number)
2, 5, 9-16 off (switch away from number)
Converter/Sampler SAMPLED INPUT COUPLING DC
ADDER OUTPUT NORM
AMPLITUDE fully clockwise
Oscilloscope Input Coupling (both channels) DC
Vertical Sensitivity (both channels) 10 V/div
Sweep Rate 100 μs/div
Sync Mode External
Display Mode Alternate
Type 1395-A POWER ON. Wait for relay to click.

d. Press the Word Generator SET 1 button.

e. With a VTVM, carefully monitor the voltage on pin 10 (see Figure 4-2) of one of the unused mainframe multipin sockets. Adjust the PULSE DC COMPONENT control on the main frame so that this voltage is 0 V. Remove the VTVM probe.

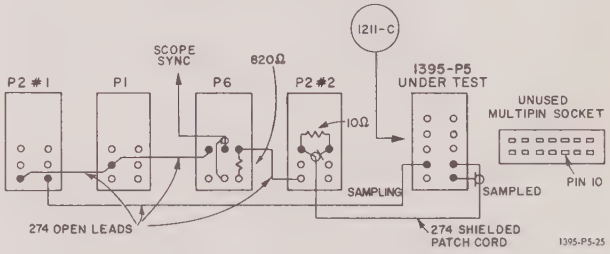


Figure 4-2. Equipment setup for minimum-performance testing.

f. Slowly adjust the Converter/Sampler THRES ADJ control to obtain the NRZ outputs shown in Figure 4-3.

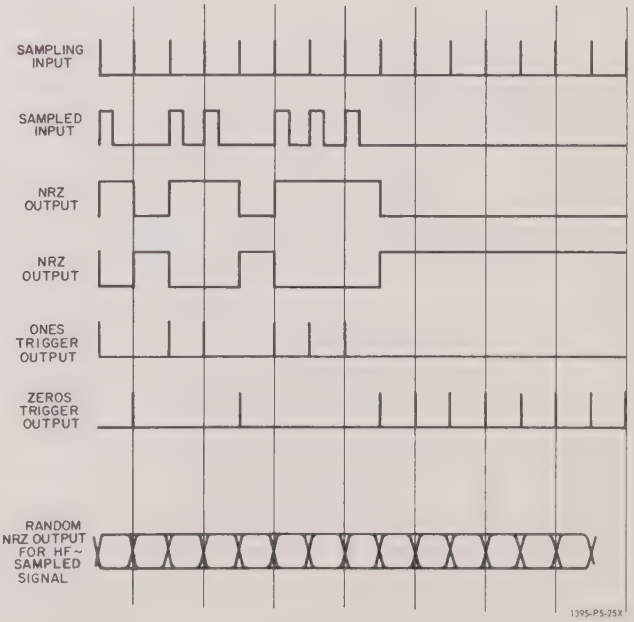


Figure 4-3. Timing diagram for input and output signals. All waveforms are delayed approximately 190 ns from the SAMPLING input.

Amplitude and Transition Times.

a. Measure the maximum amplitude of the + and - NRZ outputs to be greater than 20 V, p-p.

b. Set the INPUT COUPLING switch on the Type 1395-P5 to AC. The display should not change. Leave the INPUT COUPLING on AC.

c. Rotate the Type 1395-P5 AMPLITUDE control counterclockwise and note that the two NRZ signals' amplitudes decrease. Return the control to fully clockwise.

d. Set the oscilloscope display mode to display only the -NRZ output. Set the sweep rate to 100 ns/div.

e. Measure the unloaded -NRZ output transition (10% to 90% of full amplitude) time to be less than 100 ns. Plug a 50-Ω resistor mounted on a GR 274-MB into the -NRZ output terminals. The loaded output transition time should be less than 15 ns. The loaded output amplitude should be at least 1 V.

f. Move the oscilloscope probe from the -NRZ to the +NRZ output terminal and measure the transition time, as in step e, to be less than 100 ns. Plug the 50-Ω resistor into the +NRZ output terminals. Loaded output transition time should be less than 15 ns, and loaded output amplitude should be at least 1 V.

4.5.4 FREQUENCY RANGE.

The following procedure verifies the SAMPLING and SAMPLED INPUT frequency ranges to be as specified.

a. Remove the load from the +NRZ output terminals and connect the CH 1 probe to the +NRZ terminals.

b. Set the following controls:

PRF Unit PRF 10 CYCLES
ΔF fully counterclockwise
Oscilloscope Sweep Rate 500 ms/div
Display Mode Alternate
Converter/Sampler THRES ADJ: adjust if necessary to produce NRZ outputs

c. The NRZ output pattern should still be that shown in Figure 4-3.

d. Remove the Pulse/Delay #1 SAMPLING INPUT signal and connect the output of the high-frequency sinewave source to the SAMPLING INPUT terminals.

e. Set the following controls:

Oscilloscope Sweep Rate 10 μs/div
Sinewave frequency 2.5 MHz
Sinewave amplitude 17 V, rms (max if Type 1211 used) PRF UNIT 100 kHz, ΔF fully clockwise
Converter/Sampler THRES ADJ: Adjust, if necessary

f. The +NRZ output waveform should be the same as the SAMPLED INPUT waveform shown in Figure 4-3. The NRZ output will be delayed slightly from the SAMPLED INPUT.

g. Set the following controls:

Sinewave amplitude 0.2 V, rms

h. Remove the 2.5-MHz sinewave from the SAMPLING INPUT and connect the Pulse/Delay #1 SYNC DEL OUT to the high SAMPLING INPUT terminal. Connect the 2.5-MHz sinewave to the SAMPLED INPUT in place of the signal from Pulse/Delay Unit #2.

i. Adjustment of the THRES ADJ control should produce a random-like NRZ output, as shown in Figure 4-3.

4.5.5 TRIGGER OUTPUTS.

Test the TRIGGER OUTPUT signals of the Type 1395-P5 in the following way;

a. Set up the various instruments as in 4.5.3 a through f, except connect the CH 1 oscilloscope input to the Type 1395-P5 SAMPLED INPUT and the CH 2 input to the SAMPLING INPUT, and the PRF Frequency is 100 kHz.

b. Set the oscilloscope sweep rate to 20 μs/div. The oscilloscope display should be as shown in Figure 4-3.

c. Take the CH 2 probe from the SAMPLING INPUT and connect it to the ONES TRIGGER PULSES terminal.

d. The ONES trigger pulses should coincide closely with the presence of the ONES of the SAMPLED INPUT. The ONES trigger pulses amplitude should be greater than 10 V, and the pulse duration (between 50% points) should be approximately 70 ns.

e. Take the CH 2 probe from the ONES TRIGGER PULSES terminal and connect it to the ZEROS TRIGGER PULSES terminal.

f. The ZEROS trigger pulses should coincide closely with the presence of the ZEROS of the SAMPLED INPUT.

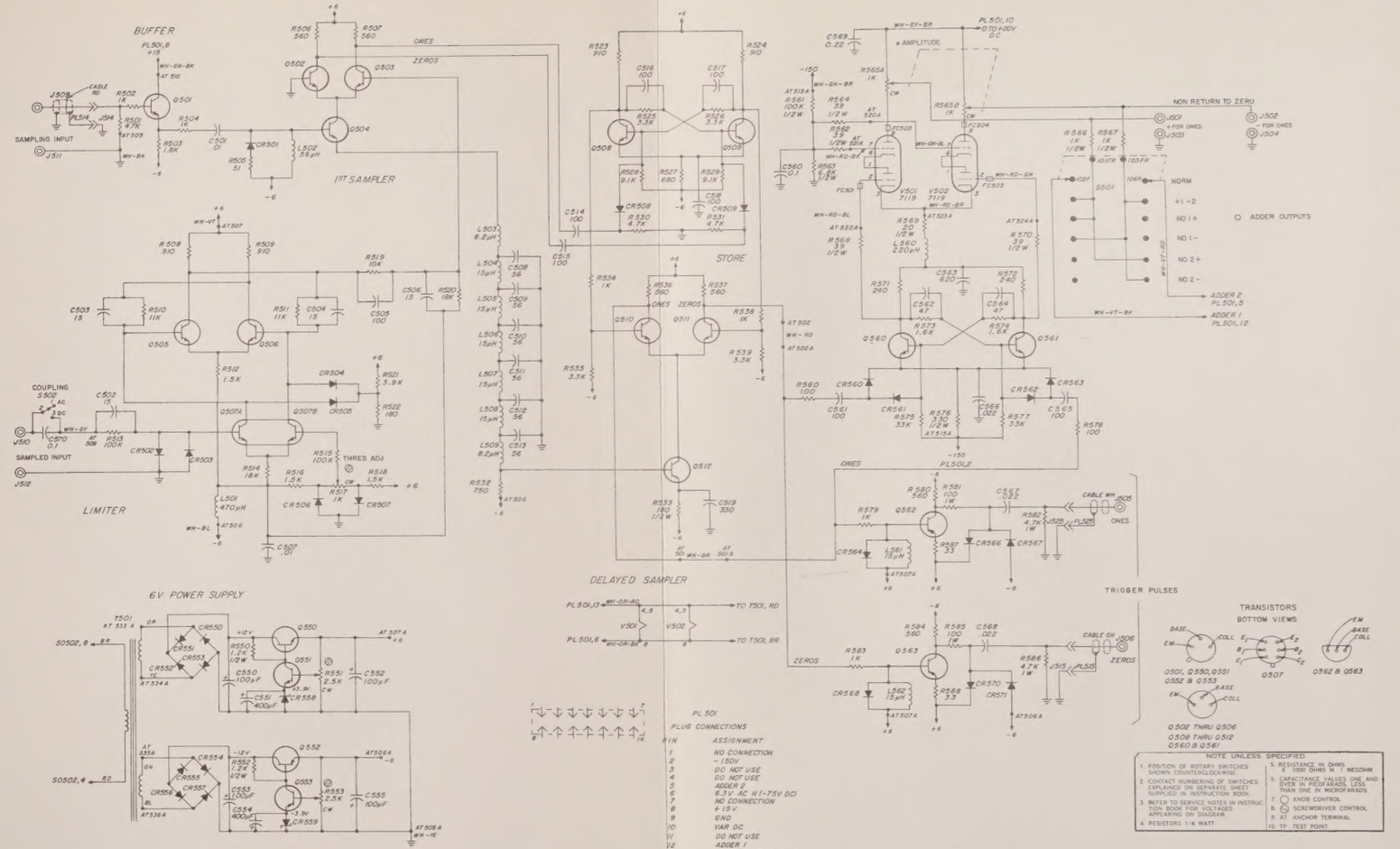
g. Set the Word Generator "1" switch to off (away from the number) and measure the ZEROS trigger pulse amplitude and duration. These should be at least 10 V and about 70 ns.

REF. NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
CAPACITORS					
C501	Ceramic, 0.01 µF +80-20% 500 V	4406-3109	72982	811, 000X5U103X	5910-977-7579
C502	Ceramic, 15 pF ±10% 500 V	4404-0158	72982	831, 15 pF ±10%	
C503	Mica, 15 pF ±5% 500 V	4640-0100	72136	CM15, 15 pF ±5%	
C504	Mica, 15 pF ±5% 500 V	4640-0100	72136	CM15, 15 pF ±5%	
C505	Ceramic, 100 pF ±5% 500 V	4404-1105	72982	831, 100 pF ±5%	
C506	Ceramic, 15 pF ±10% 500 V	4404-0158	72982	831, 15 pF ±10%	
C507	Ceramic, 0.01 µF +80-20% 500 V	4406-3109	72982	811, 000X5U103X	5910-977-7579
C508	Ceramic, 56 pF ±5% 500 V	4404-0565	72982	831, 56 pF ±5%	
C509	Ceramic, 56 pF ±5% 500 V	4404-0565	72982	831, 56 pF ±5%	
C510	Ceramic, 56 pF ±5% 500 V	4404-0565	72982	831, 56 pF ±5%	
C511	Ceramic, 56 pF ±5% 500 V	4404-0565	72982	831, 56 pF ±5%	
C512	Ceramic, 56 pF ±5% 500 V	4404-0565	72982	831, 56 pF ±5%	
C513	Ceramic, 56 pF ±5% 500 V	4404-0565	72982	831, 56 pF ±5%	
C514	Ceramic, 100 pF ±10% 500 V	4404-1108	72982	831, 100 pF ±10%	
C515	Ceramic, 100 pF ±10% 500 V	4404-1108	72982	831, 100 pF ±10%	
C516	Ceramic, 100 pF ±10% 500 V	4404-1108	72982	831, 100 pF ±10%	
C517	Ceramic, 100 pF ±10% 500 V	4404-1108	72982	831, 100 pF ±10%	
C518	Ceramic, 100 pF ±10% 500 V	4404-1108	72982	831, 100 pF ±10%	
C519	Ceramic, 330 pF ±10% 500 V	4404-1338	72982	831, 330 pF ±10%	5910-974-5702
C550	Electrolytic, 100 µF +100-10% 25 V	4450-2300	76149	20-40595	5910-799-9284
C551	Electrolytic, 400 µF +100-10% 6 V	4450-5595	80183	DEE, 400 µF +100-10%	
C552	Electrolytic, 100 µF +100-10% 25 V	4450-2300	76149	20-40595	5910-799-9284
C553	Electrolytic, 100 µF +100-10% 25 V	4450-2300	76149	20-40595	5910-799-9284
C554	Electrolytic, 400 µF +100-10% 6 V	4450-5595	80183	DEE, 400 µF +100-10%	
C555	Electrolytic, 100 µF +100-10% 25 V	4450-2300	76149	20-40595	5910-799-9284
C560	Plastic, 0.1 µF ±10% 200 V	4860-8253	84411	663UW, 0.1 µF ±10%	
C561	Ceramic, 100 pF ±10% 500 V	4404-1108	72982	831, 100 pF ±10%	
C562	Ceramic, 47 pF ±10% 500 V	4404-0478	72982	831, 47 pF ±10%	
C563	Ceramic, 620 pF ±10% 500 V	4404-1628	72982	831, 620 pF ±10%	
C564	Ceramic, 47 pF ±10% 500 V	4404-0478	72982	831, 47 pF ±10%	
C565	Ceramic, 100 pF ±10% 500 V	4404-1108	72982	831, 100 pF ±10%	
C566	Plastic, 0.1 µF ±10% 200 V	4860-8253	84411	663UW, 0.1 µF ±10%	
C567	Ceramic, 0.022 µF +80-20% 500 V	4407-3229	72982	CC63, 0.022 µF +80-20%	5910-842-2961
C568	Ceramic, 0.022 µF +80-20% 500 V	4407-3229	72982	CC63, 0.022 µF +80-20%	5910-842-2961
C569	Ceramic, 0.22 µF ±20% 25 V	4400-2052	80183	5C13, 0.22 µF ±20%	5910-974-5694
DIODES					
CR501 thru CR509	Semiconductor, type 1N4009	6082-1012	24446	1N4009	
CR550 thru CR557	Semiconductor, type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR558	Zener, 3.9-V, type 1N748A	6083-1002	07910	1N748A	5960-800-3973
CR559	Zener, 3.9-V, type 1N748A	6083-1002	07910	1N748A	5960-800-3973
CR560 thru CR564	Semiconductor, type 1N4009	6082-1012	24446	1N4009	
CR566	Semiconductor, type 1N4009	6082-1012	24446	1N4009	
CR567	Semiconductor, type 1N4009	6082-1012	24446	1N4009	
CR568	Semiconductor, type 1N4009	6082-1012	24446	1N4009	
CR570	Semiconductor, type 1N4009	6082-1012	24446	1N4009	
CR571	Semiconductor, type 1N4009	6082-1012	24446	1N4009	
ETCHED-BOARD ASSEMBLIES					
	Output and Power-Supply Etched-Board Assembly	1395-2771	24655	1395-2770	
	Sampling-Circuit, Etched-Board Assembly	1395-2781	24655	1395-2781	
FERRITE BEADS					
FC501 thru FC504	Ferrite Bead	5000-1250	02114	56-590-65/4B	
INDUCTORS					
L501	Choke, 470 µH ±10%	4300-4890	99800	3500, 470 µH ±10%	
L502	Choke, 56 µH ±10%	4300-3200	99800	2890, 56 µH ±10%	

REF. NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
INDUCTORS (Cont.)					
L503	Choke, 8.2 μH ±10%	4300-2100	99800	1537, 8.2 μH ±10%	5950-823-3168
L504	Choke, 15 μH ±10%	4300-2400	99800	1537-40, 15 μH ±10%	5950-615-0091
L505	Choke, 15 μH ±10%	4300-2400	99800	1537-40, 15 μH ±10%	5950-615-0091
L506	Choke, 15 μH ±10%	4300-2400	99800	1537-40, 15 μH ±10%	5950-615-0091
L507	Choke, 15 μH ±10%	4300-2400	99800	1527-40, 15 μH ±10%	5950-615-0091
L508	Choke, 15 μH ±10%	4300-2400	99800	1527-40, 15 μH ±10%	5950-615-0091
L509	Choke, 8.2 μH ±10%	4300-2100	99800	1537, 8.2 μH ±10%	5950-823-3168
L560	Choke, 220 μH ±10%	4300-4350	99800	3500, 220 μH ±10%	
L561	Choke, 15 μH ±10%	4300-2400	99800	1537-40, 15 μH ±10%	5950-615-0091
L562	Choke, 15 μH ±10%	4300-2400	99800	1537-40, 15 μH ±10%	5950-615-0091
JACKS					
J501	+ FOR ONES, Metal Bushing	4150-3200	07843		
J502	- FOR ONES, Metal Bushing	4150-3200	07843		
J503	Gnd, Forced Insert	5440-2727	Madel Inc.	21NF-1K	
J504	Gnd, Forced Insert	5440-2727	Madel Inc.	21NF-1K	
J505	ONES TRIGGER PULSES, Metal Bushing	4150-3200	24655	4150-3200	
J506	ZEROS TRIGGER PULSES, Metal Bushing	4150-3200	24655	4150-3200	
J507	Gnd, Forced Insert	5440-2727	Madel Inc.	2INF-1K	
J508	Gnd, Forced Insert	5440-2727	Madel Inc.	2INF-1K	
KNOBS					
	Knob, ADDER OUTPUTS	5530-0416	24655	5530-0416	
	Knob, AMPLITUDE	5540-3322	24655	5540-3322	
PLUG					
PL501	14-Connector, Female	4220-5307	02660	57-010140	
PL514	Part of Z2WIS-18L	Part of Z2			
PL515	Part of Z2WIS-18L	Part of Z2			
RESISTORS					
R501	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475	75042	BTS, 4.7 kΩ ±5%	
R502	Composition, 1 kΩ ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	
R503	Composition, 1.8 kΩ ±5% 1/4 W	6099-2185	75042	BTS, 1.8 kΩ ±5%	
R504	Composition, 1 kΩ ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	
R505	Composition, 51 Ω ±5% 1/4 W	6099-0515	75042	BTS, 51 Ω ±5%	
R506	Composition, 560 Ω ±5% 1/4 W	6099-1565	75042	BTS, 560 Ω ±5%	
R507	Composition, 560 Ω ±5% 1/4 W	6099-1565	75042	BTS, 560 Ω ±5%	
R508	Composition, 910 Ω ±5% 1/4 W	6099-1915	75042	BTS, 910 Ω ±5%	
R509	Composition, 910 Ω ±5% 1/4 W	6099-1915	75042	BTS, 910 Ω ±5%	
R510	Composition, 11 kΩ ±5% 1/4 W	6099-3115	75042	BTS, 11 kΩ ±5%	
R511	Composition, 11 kΩ ±5% 1/4 W	6099-3115	75042	BTS, 11 kΩ ±5%	
R512	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155	75042	BTS, 1.5 kΩ ±5%	
R513	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	
R514	Composition, 18 kΩ ±5% 1/4 W	6099-3185	75042	BTS, 18 kΩ ±5%	
R515	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	
R516	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155	75042	BTS, 1.5 kΩ ±5%	
R517	Composition, 1 kΩ ±10%	6041-2109	75042	BTS, 1.5 kΩ ±5%	
R518	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155	75042	BTS, 1.5 kΩ ±5%	
R519	Composition, 10 kΩ ±5% 1/4 W	6099-3105	75042	BTS, 10 kΩ ±5%	
R520	Composition, 18 kΩ ±5% 1/4 W	6099-3185	75042	BTS, 18 kΩ ±5%	
R521	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395	75042	BTS, 3.9 kΩ ±5%	
R522	Composition, 180 Ω ±5% 1/4 W	6099-1185	75042	BTS, 180 Ω ±5%	5905-279-5476
R523	Composition, 910 Ω ±5% 1/4 W	6099-1915	75042	BTS, 910 Ω ±5%	
R524	Composition, 910 Ω ±5% 1/4 W	6099-1915	75042	BTS, 910 Ω ±5%	
R525	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335	75042	BTS, 3.3 kΩ ±5%	
R526	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335	75042	BTS, 3.3 kΩ ±5%	
R527	Composition, 680 Ω ±5% 1/4 W	6099-1685	75042	BTS, 680 Ω ±5%	
R528	Composition, 9.1 kΩ ±5% 1/4 W	6099-2915	75042	BTS, 9.1 kΩ ±5%	5905-279-4619
R529	Composition, 9.1 kΩ ±5% 1/4 W	6099-2915	75042	BTS, 9.1 kΩ ±5%	5950-279-4619
R530	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475	75042	BTS, 4.7 kΩ ±5%	
R531	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475	75042	BTS, 4.7 kΩ ±5%	
R532	Composition, 750 Ω ±5% 1/4 W	6099-1755	75042	BTS, 750 Ω ±5%	
R533	Composition, 180 Ω ±5% 1/2 W	6100-1185	75042	BTS, 180 Ω ±5%	5905-279-5476
R534	Composition, 1 kΩ ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	
R535	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335	75042	BTS, 3.3 kΩ ±5%	
R536	Composition, 560 Ω ±5% 1/4 W	6099-1565	75042	BTS, 560 Ω ±5%	

PARTS LIST (Continued)

REF. NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
RESISTORS (Cont.)					
R537	Composition, 560 Ω ±5% 1/4 W	6099-1565	75042	BTS, 560 Ω ±5%	
R538	Composition, 1 kΩ ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	
R539	Composition, 3,3 kΩ ±5% 1/4 W	6099-2335	75042	BTS, 3,3 kΩ ±5%	
R550	Composition, 1,2 kΩ ±5% 1/2 W	6100-2125	01121	RC20GF122J	5905-190-8880
R551	Potentiometer, composition, 2,5 kΩ ±20%	6040-0500	24655	6040-0500	5905-931-6868
R552	Composition, 1,2 kΩ ±5% 1/2 W	6100-2125	01121	RC20GF122J	5905-190-8880
R553	Potentiometer, composition 2,5 kΩ ±20%	6040-0500	24655	6040-0500	5905-931-6868
R560	Composition, 100 Ω ±5% 1/4 W	6099-1105	75042	BTS, 100 Ω ±5%	
R561	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R562	Composition, 39 Ω ±5% 1/2 W	6100-0395	01121	RC20GF390J	5905-195-5546
R563	Composition, 6,8 kΩ ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R564	Composition, 39 Ω ±5% 1/2 W	6100-0395	01121	RC20GF390J	5905-195-5546
R565A R565B	Composition, 1 kΩ ±10%	1217-0400	24655	1217-0400	
R566	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R567	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R568	Composition, 39 Ω ±5% 1/2 W	6100-0395	01121	RC20GF390J	5905-195-5546
R569	Composition, 20 Ω ±5% 1/2 W	6100-0205	01121	RC20GF200J	5905-279-3520
R570	Composition, 39 Ω ±5% 1/2 W	6100-0395	01121	RC20GF390J	5905-195-5546
R571	Composition, 240 Ω ±5% 1/4 W	6099-1245	75042	BTS, 240 Ω ±5%	
R572	Composition, 240 Ω ±5% 1/4 W	6099-1245	75042	BTS, 240 Ω ±5%	
R573	Composition, 1,6 kΩ ±5% 1/4 W	6099-2165	75042	BTS, 1,6 kΩ ±5%	
R574	Composition, 1,6 kΩ ±5% 1/4 W	6099-2165	75042	BTS, 1,6 kΩ ±5%	
R575	Composition, 33 kΩ ±5% 1/4 W	6099-3335	75042	BTS, 33 kΩ ±5%	
R576	Composition, 330 Ω ±5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R577	Composition, 33 kΩ ±5% 1/4 W	6099-3335	75042	BTS, 33 kΩ ±5%	
R578	Composition, 100 Ω ±5% 1/4 W	6099-1105	75042	BTS, 100 Ω ±5%	
R579	Composition, 1 kΩ ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	
R580	Composition, 560 Ω ±5% 1/4 W	6099-1565	75042	BTS, 560 Ω ±5%	
R581	Composition, 100 Ω ±5% 1 W	6110-1105	01121	RC32GF101J	5905-279-2643
R582	Composition, 4,7 kΩ ±5% 1 W	6110-2475	01121	RC32GF472J	5905-299-2040
R583	Composition, 1 kΩ ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	
R584	Composition, 560 Ω ±5% 1/4 W	6099-1565	75042	BTS, 560 Ω ±5%	
R585	Composition, 100 Ω ±5% 1 W	6110-1105	01121	RC32GF101J	5905-279-2643
R586	Composition, 4,7 kΩ ±5% 1 W	6110-2475	01121	RC32GF472J	5905-299-2040
R587	Composition, 33 Ω ±10% 1/4 W	6099-0339	75042	BTS, 33 Ω ±10%	
R588	Composition, 33 Ω ±10% 1/4 W	6099-0339	75042	BTS, 33 Ω ±10%	
SOCKETS					
SO501	Socket	7540-1150	81350	TS103C02	
SO502	Socket	7540-1150	81350	TS103C02	
SWITCHES					
S501	Rotary Wafer, ADDER OUTPUTS	7890-4130	76854	Type F	
S502	Toggle, spdt COUPLING	7910-0790	95146	MST-105D	
TUBES					
T501	Transformer	0746-4500	24655	0746-4500	
TRANSISTORS					
Q501	Type 2N708	8210-3089	24454	2N708	
Q502 thru Q506	Type 2N3563	8210-1066	07263	2N3563	
Q507A Q507B	Transistors	8210-1101	24454	4JX12G1162	
Q508 thru Q512	Type 2N3563	8210-1066	07263	2N3563	
Q550	Type 2N696	8210-1033	24454	2N696	5960-840-3561
Q551	Type 2N696	8210-1033	24454	2N696	5960-840-3561
Q552	Type 2N1131	8210-1025	96214	2N1131	5960-788-8644
Q553	Type 2N1131	8210-1025	96214	2N1131	5960-788-8644
Q560	Type 2N3563	8210-1066	07263	2N3563	
Q561	Type 2N3563	8210-1066	07263	2N3563	
Q562	Type 2N3906	8210-1112	93916	2N3906	
Q563	Type 2N3906	8210-1112	93916	2N3906	
TUBES					
V501	Type 7119	8380-7119	73445	7119	
V502	Type 7119	8380-7119	73445	7119	


BUFFER
1ST SAMPLER
STORE
DELAYED SAMPLER
LIMITER
6V POWER SUPPLY
TRIGGER PULSES
NON RETURN TO ZERO
ADDER OUTPUTS
TRANSISTORS
BOTTOM VIEWS
PL 501 PLUG CONNECTIONS
PIN ASSIGNMENT
1 NO CONNECTION
2 -150V
3 DO NOT USE
4 DO NOT USE
5 ADDER 2
6 6.3 V AC N (-75 V DC)
7 NO CONNECTION
8 +15 V
9 GND
10 VAR DC
11 DO NOT USE
12 ADDER 1
13 6.3 V AC N(-75 V DC)
14 NO CONNECTION
NOTE UNLESS SPECIFIED
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

Figure 4-4. Schematic diagram of the Type 1395-P5 NRZ Converter/Sampler Unit.

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FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.
00656	Aerovox Corp., New Bedford, Mass.
01009	Alden Products Co., Brockton, Mass.
01121	Allen-Bradley, Co., Milwaukee, Wisc.
01295	Texas Instruments, Inc., Dallas, Texas
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477
02606	Fenwal Lab. Inc., Morton Grove, Ill.
02660	Amphenol Electronics Corp., Broadview, Ill.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201
03636	Grayburne, Yonkers, N. Y. 10701
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.
03911	Clairex Corp., New York, N. Y. 10001
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702
05624	Barber-Colman Co., Rockford, Ill. 61101
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.
07261	Avnet Corp., Culver City, Calif. 90230
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.
07387	Birtcher Corp., No. Los Angeles, Calif.
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004
07828	Bodine Corp., Bridgeport, Conn. 06605
07829	Bodine Electric Co., Chicago, Ill. 60618
07910	Continental Device Corp., Hawthorne, Calif.
07983	State Labs Inc., N. Y., N. Y. 10003
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115
08730	Vemaline Prod. Co., Franklin Lakes, N. J.
09213	General Electric Semiconductor, Buffalo, N. Y.
09823	Burgess Battery Co., Freeport, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852
11599	Chandler Evans Corp., W. Hartford, Conn.
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140
12672	RCA Commercial Receiving Tube and Semiconductor Div., Woodridge, N.J.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820
12954	Dickson Electronics Corp., Scottsdale, Ariz.
13327	Solitrone Devices, Tappan, N. Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Florida
14655	Cornell Dubilier Electric Co., Newark N. J.
14674	Corning Glass Works, Corning, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T, Lawrence, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co., Spruce Pine, N. C.
19701	Electra Mfg. Co., Independence, Kansas 67301
21335	Fafnir Bearing Co., New Briton, Conn.
24446	G. E. Schenectady, N. Y. 12305
24454	G. E., Electronic Comp., Syracuse, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co., W. Concord, Mass 01781
26806	American Zettler Inc., Costa Mesa, Calif.
28520	Hayman Mfg. Co., Kenilworth, N. J.
28959	Hoffman Electronics Corp., El Monte, Calif.
30874	International Business Machines, Armonk, N.Y.
32001	Jensen Mfg. Co., Chicago, Ill. 60638
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.
38443	Marlin-Rockwell Corp., Jamestown, N. Y.
40931	Honeywell Inc., Minneapolis, Minn. 55408
42190	Muter Co., Chicago, Ill. 60638
42498	National Co. Inc., Melrose, Mass. 02176
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904
49671	RCA, New York, N. Y.
49956	Raytheon Mfg. Co., Waltham, Mass. 02154
53021	Sangamo Electric Co., Springfield, Ill. 62705
54294	Shallcross Mfg. Co., Selma, N. C.
54715	Shure Brothers, Inc., Evanston, Ill.
56289	Sprague Electric Co., N. Adams, Mass.
59730	Thomas and Betts Co., Elizabeth, N. J. 07207
59875	TRW Inc. (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg. Co., Torrington, Conn.
61637	Union Carbide Corp., New York, N. Y. 10017
61864	United-Carr Fastener Corp., Boston, Mass.
63060	Victoreen Instrument Co., Inc., Cleveland, Ohio
63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.
65083	Westinghouse (Lamp Div), Bloomfield, N. J.
65092	Weston Instruments, Weston-Newark, Newark, N. J.
70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607
70563	Amperite Co., Union City, N. J. 07087
70903	Belden Mfg. Co., Chicago, Ill. 60644
71126	Bronson, Homer D., Co., Beacon Falls, Conn.
71294	Canfield, H. O. Co., Clifton Forge, Va. 24422
71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.
71590	Centralab, Inc., Milwaukee, Wisc. 53212
71666	Continental Carbon Co., Inc., New York, N. Y.
71707	Coto Coil Co. Inc., Providence, R. I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624
71823	Darnell Corp., Ltd., Downey, Calif. 90241
72136	Electro Motive Mfg. Co., Willmington, Conn.
72259	Nytronics Inc., Berkeley Heights, N. J. 07922
72619	Dialight Co., Brooklyn, N. Y. 11237
72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104
72765	Drake Mfg. Co., Chicago, Ill. 60656
72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp., Union, N. J. 07083
72982	Erie Technological Products Inc., Erie, Penn.
73445	Amperex Electronics Co., Hicksville, N. Y.
73559	Carling Electric Co., W. Hartford, Conn.
73690	Elco Resistor Co., New York, N. Y.
73899	J. F. D. Electronics Corp., Brooklyn, N. Y.
74193	Heinemann Electric Co., Trenton, N. J.
74861	Industrial Condenser Corp., Chicago, Ill.
74970	E. F. Johnson Co., Waseca, Minn. 56093
75042	IRC Inc., Philadelphia, Penn. 19108
75382	Kulka Electric Corp., Mt. Vernon, N. Y.
75608	Linden and Co., Providence, R. I.
75915	Littelfuse, Inc., Des Plaines, Ill. 60016
76005	Lord Mfg. Co., Erie, Penn. 16512
76487	James Millen Mfg. Co., Malden, Mass. 02148
76545	Mueller Electric Co., Cleveland, Ohio 44114
76684	National Tube Co., Pittsburg, Penn.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77147	Patton MacGuyer Co., Providence, R. I.
77166	Pass-Seymour, Syracuse, N. Y.
77263	Pierce Roberts Rubber Co., Trenton, N. J.
77339	Positive Lockwasher Co., Newark , N. J.
77542	Ray-O-Vac Co., Madison, Wisc.
77630	TRW, Electronic Component Div., Camden, N. J. 08103
77638	General Instruments Corp., Brooklyn, N. Y.
78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120
78277	Sigma Instruments Inc., S. Braintree, Mass.
78488	Stackpole Carbon Co., St. Marys, Penn.
78553	Tinnerman Products, Inc., Cleveland, Ohio
79089	RCA, Commercial Receiving Tube and Semiconductor Div., Harrison, N. J.
79725	Wiremold Co., Hartford, Conn. 06110
79963	Zierick Mfg. Co., New Rochelle, N. Y.
80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio
80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.
80131	Electronic Industries Assoc., Washington, D.C.
80211	Motorola Inc., Franklin Park, Ill. 60131
80258	Standard Oil Co., Lafeyette, Ind.
80294	Bourns Inc., Riverside, Calif. 92506
80431	Air Filter Corp., Milwaukee, Wisc. 53218
80583	Hammarlund Co. Inc., New York, N. Y.
80740	Beckman Instruments, Inc., Fullerton, Calif.
81073	Grayhill Inc., LaGrange, Ill. 60525
81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp., Yonkers, N. Y.
81831	Filton Co., Flushing, L. I., N. Y
81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
82273	Indiana Pattern and Model Works, LaPort, Ind.
82389	Switchcraft Inc., Chicago, Ill. 60630
82647	Metals and Controls Inc., Attleboro, Mass.
82807	Milwaukee Resistor Co., Milwaukee, Wisc.
83058	Carr Fastener Co., Cambridge, Mass.
83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
83361	Bearing Specialty Co., San Francisco, Calif.
83587	Solar Electric Corp., Warren, Penn.
83740	Union Carbide Corp., New York, N. Y. 10017
84411	TRW Capacitor Div., Ogallala, Nebr.
84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
84971	TA Mfg. Corp., Los Angeles, Calif.
86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
86684	RCA (Electrical Component and Devices) Harrison, N. J.
88140	Cutler-Hammer Inc., Lincoln, Ill.
88219	Gould Nat. Batteries Inc., Trenton, N. J.
88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
88627	K and G Mfg. Co., New York, N. Y.
89482	Holtzer Cabot Corp., Boston, Mass.
89665	United Transformer Co., Chicago, Ill.
90201	Mallory Capacitor Co., Indianapolis, Ind.
90750	Westinghouse Electric Corp., Boston, Mass.
90952	Hardware Products Co., Reading, Penn. 19602
91032	Continental Wire Corp., York, Penn. 17405
91146	ITT Cannon Electric Inc., Salem, Mass.
91293	Johanson Mfg. Co., Boonton, N. J. 07005
91598	Chandler Co., Wethersfield, Conn. 06109
91637	Dale Electronics Inc., Columbus, Nebr.
91662	Elco Corp., Willow Grove, Penn.
91719	General Instruments, Inc., Dallas, Texas
91929	Honeywell Inc., Freeport, Ill.
92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
92678	Edgerton, Germeshausen and Grier, Boston, Mass.
93332	Sylvania Electric Products, Inc., Woburn, Mass.
93916	Cramer Products Co., New York, N. Y. 10013
94144	Raytheon Co. Components Div., Quincy, Mass.
94154	Tung Sol Electric Inc., Newark, N. J.
95076	Garde Mfg. Co., Cumberland, R. I.
95146	Alco Electronics Mfg. Co., Lawrence, Mass.
95238	Continental Connector Corp., Woodside, N. Y.
95275	Vitramon, Inc., Bridgeport, Conn.
95354	Methode Mfg. Co., Chicago, Ill.
95412	General Electric Co., Schenectady, N. Y.
95794	Ansconda American Brass Co., Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
96214	Texas Instruments Inc., Dallas, Texas 75209
96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
96341	Microwave Associates Inc., Burlington, Mass.
96906	Military Standards
97966	CBS Electronics Div. of Columbia Broadcasting Systems, Danvers, Mass.
98291	Sealectro Corp., Mamaroneck. N. Y. 10544
98821	North Hills Electronics Inc., Glen Cove, N. Y.
99180	Transitron Electronics Corp., Melrose, Mass.
99378	Atlee Corp., Winchester, Mass. 01890
99800	Delevan Electronics Corp., E. Aurora, N. Y.

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